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The Vapor Tension of Silver and Gold.

The instalment of Dr. J. W. Richards' Metallurgical Calculations, published in our present issue and dealing with the metallurgy of silver and gold, is particularly interesting and instructive. It is probably here for the first time that tables of the vapor tension of silver and gold are given. It is true, these are only estimates, but logical estimates based on plausible and practical rules, and undoubtedly the best estimates that can be made at present. As far as comparisons are possible with actual observations, the agreement is "encouraging," as the author says; we might say, it is surprisingly good. And as far as practical application of these tables is concerned, the figures will certainly be near enough the truth to base on them numerical calculations which may be relied upon as a first approximation. For that is the beauty of these tables, that they permit to draw from them very practical conclusions, and to base on them important commercial considerations.

* * *

There may still be practical men who consider "vapor tensions" to be pretty playthings for scientists. Possibly in some purely theoretical books they are handled that way. But if we consider that the vapor tension of a metal at a given temperature is nothing more nor less than a numerical indication of the extent to which the metal vaporizes at that temperature, and since these tables of Dr. Richards show that the vapor tension of silver at least reaches appreciable amounts at the temperatures of our smelting furnaces, they become immediately a matter of serious importance. The tables clearly indicate the danger of serious losses in melting in open furnaces where furnace gases pass over the metal. As Dr. Richards says, "Every smelter and refiner of the precious metals should be familiar with these facts, and draw conclusions from them useful to the conduct of his business."

Electric Furnace Reactions Under High Pressure.

It is not always realized sufficiently that our ordinary chemistry relates to phenomena taking place within an extremely narrow range of temperature and pressure. From observations within this narrow range we are liable to deduct generalizations which, as such, are wrong. An example is Thomson's rule. At the zero point of absolute temperature it is strictly correct. At our ordinary temperature, which is relatively near absolute zero, it is approximately correct for most reactions, since the second term in the Gibbs-Helmholtz equation, which distinguishes it from Thomson's rule, is in most cases negligible at ordinary temperatures. This term contains the absolute temperature as one factor. The higher we go in the temperature the greater is the danger in applying Thomson's rule. Because Thomson's rule is practically true in most cases

at ordinary temperatures, it would, therefore, be wrong to conclude that it is also true at high temperatures. We may have at high temperatures a chemistry quite different from that of low temperatures. Elements which do not react at all at low temperatures, like the nitrogen and oxygen in the air, combine eagerly at the temperature of the electric arc.

* * *

Enormous progress has been made in recent years in extending the range of temperatures available for research, in both directions, towards high and low temperatures. High temperatures are the field of electric furnace research, and it is unnecessary to point out here how this research has resulted in the establishment of a number of new important industries like those of carborundum and calcium carbide. Further avenues of research are opened by not only varying the temperature but also the pressure. Some very interesting electric furnace experiments with high pressures are described in the paper by Dr. Hutton and Mr. Petavel in our present issue. The possibilities of a process of direct reduction of alumina by means of carbon, discussed by the authors, are so attractive—even though the matter is not beyond the purely experimental stage—that these high-pressure high-temperature researches should attract most careful attention. It would seem promising to apply the same method to other reactions, and to study them not only at high gaseous pressures but at low pressures, for the high-pressure furnace appears to be equally suitable as a vacuum furnace. Messrs. Hutton and Petavel certainly deserve our thanks for having opened a new field with considerable skill, perseverance and success.

Changes in British Patent Law.

Some recent changes in British patent law are interesting on account of the importance of the new rules to manufacturers, and should be especially interesting to our readers, because in the arguments made for the new law the development of the dyestuff industry has played an important part. It is a fact that the dyestuff industry was born in England. Perkin's discovery of mauve and A. W. Hofmann's pioneer work in England are history. But it is also unnecessary to describe how England permitted Hofmann to return to his native country, Germany, and how the whole dyestuff industry gradually passed from England over to Germany. Out of all patents granted in England in 1906 for dyes, 95 per cent were granted to foreigners. Moreover, the manufacture was carried on almost completely abroad, and the products imported into Great Britain in large quantities. In other words, the British patents were merely used for the purpose of shutting others off from the British market, not for creating a productive British industry.

* * *

The method by which England tries to meet this situation was already foreshadowed by the action of Canada, where an act was passed in 1903, according to which a patent is null and void at the end of two years unless the patentee shall commence and continuously carry out in Canada the construction or manufacture of the invention patented in such a manner that any person desiring to use it may obtain it at a reasonable price by some manufactory in Canada. Further, "if after twelve months from the granting or authorized extension of a patent the patentee imports into Canada the invention for which the patent is granted, such patent shall be void as to the interest of the person so importing." The chief features of the new English patent law, to which we shall now refer, are in the same direction.

* * *

One of the fundamentally new features of the British law, which went into effect at the beginning of this year, is that before an English patent is granted there shall be a search of the prior art, and the principle, long recognized in this country and elsewhere, of refusing a grant of a patent on the ground of anticipation has now, for the first time, been adopted in England. More important, however, are the new rules as to the use of a patent. There is a rule that any person interested may present a petition to the Board of Trade (a British government department which has power and control in patent matters) alleging that the reasonable requirements of the public with respect to a patented invention have not been satisfied, and praying for the grant of a compulsory license, or, in the alternative, for the revocation of the patent. The Board of Trade are to consider the petition, and if the parties do not come to an arrangement between themselves, the Board, if satisfied that a *prima facie* case has been made out, must report the petition to the Court, but if the Board are not so satisfied they may dismiss the petition. When such a petition is referred to the Court, and it is proved to the satisfaction of the Court that the reasonable requirements of the public with reference to the patented invention have not been satisfied, the patentee may be ordered by the Court to grant licenses on such terms as the Court may think just; if the Court is of opinion that the reasonable requirements of the public will not be satisfied by the grant of licenses, the patent may be revoked. An order of revocation will not, however, be made before the expiration of three years from the date of the patent, or if the patentee gives satisfactory reasons for his default.

* * *

It will be, of course, of greatest importance to see how the term "reasonable requirements of the public" will be understood by the British courts. Other important provisions are intended to prevent a patentee, whether British or foreign, from placing such restrictions on the use of his invention that the public is unduly hampered in its use of it. In any contract made in relation to the sale or lease of or license to use or work any article or process patented it shall be illegal to insert a condition: "to prohibit or restrict the purchaser, lessee or licensee from using any article or class of articles, whether patented or not, or any patented process, supplied or owned by any person other than the seller, lessor or licensor, or his nominees; or to require the purchaser, lessee or licensee to acquire from the seller, lessor or licensor, or his nominees, any article or class of articles not protected by the patent." Any such conditions in a contract shall be null and void, as being in restraint of trade and contrary to public policy. It will be seen that the new British patent law contains very important innovations. This country, like others, believes in protective duties to aid the home industry. England believes

in free trade, and tries to create home industries by its patent law. It will be worth while watching how this scheme will work in practice.

The Industrial Situation.

Commercial developments in the past few months prompt us to scrutinize, from a fresh viewpoint, if possible, what we have done in the past ten years, that we should have to face the conditions which now confront us. These have been years of apparently great prosperity, yet we have less than we expected of strength financially, and of momentum industrially. Not to anticipate too much, we can say at least that our profits appear to be, to some extent, paper profits, while our increasing rate of production appears to have overstocked us. We have been primarily an agricultural nation, but it is not from agriculture that any trouble has developed. Our past crops have been finally consumed, and there is demand for more of these products. By various enlightened methods the dangers of crop famine have been reduced to almost negligible proportions.

* * *

In manufacturing, one naturally turns to the iron industry. For ten years—eleven, to be complete—each year, with the exception of 1904, has broken all previous production records. The year 1898 broke the 1897 production record by more than two million tons, turning out 11,773,934 tons. Last year completed the period, with an output of 25,781,361 tons. Apparently there was no expectation on the part of our iron producers that demand was to call a halt, since new furnaces have been projected right and left. During 1907 there were completed and blown in, fifteen absolutely new furnaces, with an annual capacity of 2,100,000 tons, the last accretion being in October. They brought the country up to January 1, 1908, with an actual productive capacity in excess of 28,000,000 tons, and yet that was not all. There were new furnaces being built, many of them almost completed, and all, no doubt, ultimately to be completed, having an annual capacity of 3,500,000 tons, so that right in the close of this period of activity an annual production of 31,500,000 tons was being provided for. Our exports need not be considered. They were a trifle less in 1907 than in 1906, and do not promise a gain this year. At best they have not represented a pig-iron equivalent of more than a million and a half tons, negligible against a capacity for more than thirty millions. Evidently the expectation of producers was that as the country increased its purchases year by year, it would continue indefinitely to do so. Possibly they failed to observe that men do not eat iron, but put it into employment.

* * *

During the past ten years, 1898 to 1907, there have been produced in the United States 181,470,757 gross tons of pig iron. Our population being about 86,800,000, there have been produced in ten years 2.1 tons of pig iron for every man, woman and child in the United States. In the preceding ten years the production was 82,236,958 tons. In all the years prior to 1888 the aggregate was less than 100,000,000 tons, so that in the last ten years we have made more than in all the past. A relatively small part of the iron used disappears. What was produced two or three decades ago may be lost, but the tonnage then made was insignificant. The bulk of what has been produced in the past two decades has survived. Occasionally it may be remelted in the foundry cupola or the open-hearth furnace, or the pieces may be stuck together by heating "piles on boards" and the other devices of the iron mill. Certainly more than two tons per capita have survived, and with the exclusive use of two tons, each one of us in this country can accomplish quite a good bit, yet provision is being made for distributing a third of a ton additional every year, so that while we are using two tons apiece now, six years hence we should be using four tons apiece. It should not be new to our readers that the recent pace in expansion has been rapid. In our market review last March we discussed the prospective new capacity and concluded: "The presentation should be conclusive that a very large increase in production is possible over 1906, while trade conditions do not warrant the belief that there will be any material increase in consumptive demand." The actual increase in make in 1907 was 475,000 tons, or less than 2 per cent, and the year closed with a capacity equal to an increase of more than 10 per cent. This is really a period in which we are removing iron ore from the ground, dissociating the iron, and not consuming it, but putting it into use. We are not in the infancy of the period, but have progressed well along to maturity. This may lead to the conclusion, then, that we must look upon the past ten years in the iron industry not so much as setting a pace as accomplishing a result, and halting at its close until more results are required.

* * *

In our international trade we have had a tendency to overlook forces at work which were readily discernible. When our trade in 1898 showed the record favorable balance of trade of $620,000,000 there was congratulation. The following year there was a favorable balance of $476,000,000, which was the best, barring 1898, while 1900 established a new record, with $649,000,000, and then came 1901 with $585,000,000. In these four years, 1898 to 1901, our apparent favorable balance of trade was $2,331,000,000, or $583,000,000 per year. That has furnished the basis for much of our prosperity. But of late years the balance has not been so good; in the past four years it has averaged only $460,000,000 per year. That decrease is bad, but it is far from being the whole story. In 1898 to 1901 our average commerce, imports plus exports, was $2,155,000,000 per year. In the past four years it has been $2,940,000,000 per year. The apparent favorable balance of trade is not net profit; it is gross earnings, from which must be deducted expenses, such as the freights we pay on both incoming and outgoing merchandise, the money our tourists spend abroad, a percentage of loss on the total business transacted, because we always undervalue our imports and overvalue our exports, and a number of other items. The business we transacted in the past four years was more than a third larger than that in 1898 to 1901, while our gross earnings were more than one-fifth less. Necessarily our net profits have been greatly reduced, yet in the recent past we have seen much of glorification over the enormous amount of foreign business we have been doing, with no serious thought as to whether we are gaining or losing by it. Not having provided a basis for the future with careful foresight, we must now seek one in our embarrassment.

The Iron and Steel Market.

The iron trade has settled down to a long wait for the rehabilitation of demand. The policy which dictated the maintenance of 1907 steel prices was an unhopeful one, because it did not regognize that demand could be stimuiated by reduction in prices; *i. e.*, by anything at all. At first the policy was criticized; it still is, but in much less degree, because more men have become convinced that there is little business to be had at any price.

The mills are operating, on an average, between 30 and 40 per cent of the normal. Statements are frequently made crediting them with 50 per cent or more. Such statements are either untrue fundamentally or err in misusing the term normal. For almost three years, up to last November, the American iron and steel industry was operating up to its capacity, which was continually increasing, and normal in this connection should mean nothing but operating to existing capacity; or, in other words, at a rate equal to the greatest yet attained.

As predicted in last report, ore prices were fixed for the forthcoming season at the same rates as prevailed last year. A meeting was held in Cleveland Feb. 7 at which all but one of the ore interests were present, and they, the absent interest afterwards concurring, expressed the determination not to sell any ores for the coming season at less than last year's rates, with the same analysis basis. These rates are:

Old range Bessemer	$5.00
Old range non-Bessemer	4.20
Mesabi Bessemer	4.75
Mesabi non-Bessemer	4.00

These prices are f. o. b. Lake Erie docks. The Bessemer ore basis is 55 per cent iron in the natural state, with 10 per cent moisture, and .045 per cent phosphorus when dried at 212°. The non-Bessemer basis is 51.50 per cent iron in the natural state, with 12 per cent moisture. Ores above and below the basis take premiums and penalties. This basis was first established last year. For a number of years prior the basis was 63 per cent iron for Bessemer and 60 per cent iron for non-Bessemer ores, dried at 212°, with the same moisture content in the natural state, which made the percentages in the natural state 56.70 and 52.80 per cent, respectively. The penalty system for ores under the base is substantially the principle that the iron is sold on a unit basis, which is inequitable to the consumer, as it does not reimburse him for the extra coke and limestone consumed in smelting.

It is not expected that any ores will be sold for months to come on the established or any other basis. The Cleveland ore firms were at first much averse to fixing any prices at this time, and were induced to take the action only by the persuasion of the steel interests, who wished assistance in the efforts to maintain old prices for steel products.

Very little Lake Superior ore will be mined this year. A preliminary statement of the United States Geological Survey indicates that production in the Lake Superior region last year was about 43,000,000 tons, and production of the entire country between 52,000,000 and 54,000,000 tons. The Lake Superior production is based substantially on the prospective make in the districts tributary to it for the period July 1 to July 1. As districts using other than Lake Superior ores have been changing their capacity but little, it is not necessary to segregate. The pig iron output from July 1, 1906, to July 1, 1907, was about 26,000,000 tons, corresponding to the production of 47,750,000 tons of iron ore in the calendar year 1906. The prospective pig iron output from July 1, 1907, to July 1, 1908, allowing for the new furnaces coming in, was about 28,750,000 tons, and on this the production of about 53,000,000 tons of iron ore in the calendar year 1907 was based. The figures correspond very well. However, the actual make in the second half of 1907 was only 12,300,000 tons, and the prospects are that the make in the present half-year will lie between 7,000,000 and 9,000,000 tons, making a production for the year, July 1, 1907, to July 1, 1908, something like 8,500,000 tons less than the prospect. It is not probable that the prospective make for the twelvemonth following July 1 next will approach the output of the calendar year 1907, even curtailed as it was in the closing two months to a total of 25,781,361 tons. Supposing it to reach 20,000,000 tons, there would be a surplus of ore to take care of 8,500,000 tons of it, leaving only 11,500,000 tons to be taken care of by ore production this year, just 40 per cent of the pig-iron make on which the 1907 ore production was based. Assuming so much as 25,000,000 tons of pig iron expected for the twelvemonth beginning July next, there would be 16,500,000 tons to provide for, less than 60 per cent of the previous prospect, so that it is reasonable to conclude that iron ore production in 1908 will lie between 40 and 60 per cent of the production of 1907. Pig iron production in 1908, on the other hand, is likely to be two-thirds the output of 1907.

Pig Iron.

On the whole, there has been an increase in pig iron production by steel interests in February as compared with January, while the output by merchant furnaces has decreased. The steel interests were quick to blow out their furnaces on the sudden decline in demand, while the merchant furnaces, largely involving detached operations, accumulated some stocks of different grades before blowing out in order to supply such demand as might develop during the period of idleness. The market was extremely dull in the early part of February, but in the closing fortnight of the month took on a little more activity. The buying has been of the most conservative character and prompted only by necessity. The market is steadier than a month ago and is not materially lower. It can be fairly quoted, f. o. b. valley furnace, at $17 for Bessemer, $16 for No. 2 foundry and basic, $16 to $16.25 for malleable, and $15.25 for gray forge. An agreement upon foundry iron among a number of central western furnaces has an academic interest only at present, since iron can be bought at less than the agreed prices. These are on the basis of $17, delivered Pittsburg, Youngstown, Cleveland and Detroit, plus the switching charge from the local furnace nearest the point of delivery.

Steel.

It is understood that the mills are adhering to the agreement at $28, Pittsburg, for standard billets, and $29, Pittsburg, for sheet bars, with full extras on sizes and carbons. On account of the existence of small stocks here and there, and the possibility of putting through some trades with scrap and pig iron, some middlemen are able to offer small lots of billets at $1 to $1.50 under the agreed price. With so very light a demand these offerings make the market, but any ordinary activity would, it is to be presumed, clean up all such cheap steel.

Finished Material.

Fresh sales have been extremely light. They are lighter than they would be in normally dull times. It is a question whether the extreme stagnation is attributable more to lack of confidence in the programme of maintaining finished steel prices, or to inability of consumers to finance transactions. Certainly while general business is quiet there is less iron and steel business than there should be.

There has been a disappointment in rails. The Pennsylvania system, which is usually the leader in placing season orders, bought only 55,000 tons for 1908. After last season's deliveries were closed it had 30,000 tons still due, while besides this it had rolled, under special arrangements, 11,000 tons, making its total supply for the current year 96,000 tons. For four preceding years its purchases have ranged from a minimum of 102,000 tons to a maximum of 225,000 tons. The Pennsylvania system embraces 5 per cent in length, and much more in interest, of the country's total railroad mileage, so

that the rail outlook is very bad, seeing that the 1906 production amounted to about 4,000,000 tons.

While the size of the Pennsylvania order was a disappointment, another came in that other railroads did not follow as they have usually done. Two-thirds of the tin-plate mills of the country are in operation, this branch showing more activity than any other. Ordinarily, however, the months of February and March see all the tin mills in operation, with shipments in excess of production and drawn partly from stocks accumulated against the canning season. Tin-plate production in the three months since December 1 last has been just about one-half what it was a year ago, despite the traditions that tin plate fares best when other lines are dull, that men must eat, and that nature does not suspend the laws of decay as to canning crops when industrial conditions are bad.

No changes have been made in finished steel prices, the producers still adhering to the policy that prices should be maintained through this period of stagnation and be reduced only when conditions show that there is some activity ahead. Plates remain at $1.70, but are shaded by some smaller mills to $1.60; shapes are on the $1.70 basis, but one mill at least has been doing $1.60; merchant steel bars are $1.60, tin plates $3.70, black sheets $2.50 and galvanized sheets $3.55. Wire products are firm, on the basis of $2.05 for nails. The iron mills have advanced their prices to the basis of $1.50 for Pittsburg delivery, $1.50, f. o. b. Pittsburg, for eastern delivery, and $1.47, f. o. b. Pittsburg, for western delivery. The advance was made partly in deference to the strongly expressed wishes of the steel interests, and partly because the low prices had brought out little business.

American Institute of Mining Engineers.

The annual business meeting of the American Institute of Mining Engineers was held in the United Engineers' Building, in New York City, on Feb. 18. The following officers were elected: John Hays Hammond, president; J. Parke Channing, John B. Farish and F. W. Denton, vice-presidents; Joseph H. Shockley, C. R. Corning and R. Van A. Norris, members of council; James Douglas, James F. Kemp and Albert R. Ledoux, directors; R. W. Raymond, secretary.

In the absence of President Hammond, who is ill at San Francisco, Vice-President Prof. Henry M. Howe was in the chair at the evening session of Feb. 18. Dr. R. W. Raymond presented in abstract a suggestive paper on Humboldt and Swedenborg as mining engineers. Mr. David B. Rushmore read an interesting paper on electric power in steel mills, profusely illustrated by lantern slides and covering the principal features of generation and applications of electric power down to the application to the driving of rolling mills.

At the morning session of Feb. 19, Mr. F. E. Junge spoke on the use of waste gases in German steel works.

The Watertown Arsenal Steel Tests.

Mr. J. E. Howard presented a paper on the scope of the work of the testing department of the Watertown Arsenal in its relation to the metallurgy of steel. As to tests of ingot metal, open-hearth, Bessemer and crucible steel, fluid compressed and uncompressed, the chief item of the inquiry is to be the conditions of structural soundness and continuity of the metal in the ingot state, because this is of utmost importance in the behavior of the steel after having undergone further treatment.

Other subjects of systematic tests will be blooms, billets and rolled and hammered shapes from ingots, including finished products of all kinds. The object of these tests will be to determine the influence of the working temperature on final properties, to determine how much work is essential at a given temperature to get maximum tensile strength, etc.; also reductions in the rolls or under the hammer and the number of passes in the rolls will be inquired into.

In the discussion of this paper, in which Messrs. R. W. Mahon, A. A. Stevenson, C. L. Huston, F. N. Speller, J. P. Snow and C. S. Churchill participated, various subjects were proposed which should be investigated at the Watertown Arsenal laboratory.

Mr. C. L. Huston (in a communicated discussion) pointed out how, by varying the method of heating and the manipulation in the rolls and the proportion of the test pieces, it is possible to adjust yield point, elongation and reduction of area. Besides the proposed division into grades, such as open-hearth, Bessemer and crucible steel, a careful distinction should be made between mild steels, medium-carbon steels and high-carbon steels and the various special alloy steels, because these different classes behave very differently in cooling and solidifying from the molten state, and this has naturally a great effect on uniformity in chemical composition and structural continuity. It would seem probable that work performed on steel at the higher temperatures above the recalescence point will have little effect on the properties of the final product, because the work done at the higher temperatures has only a small permanent influence on the structure of the steel. For boiler and structural work Mr. Huston favors the use of soft steel, on account of greater safety.

Mr. F. N. Speller expressed his agreement with the opinion of Mr. A. A. Stevenson, that all investigations of the origin of the defects in steel should go back of the ingot and should start with the metal from the blast furnace, taking duly into consideration its composition, treatment, refining, ladle reaction, oxidation, etc. As an instance, he mentioned the manufacture of soft steel, using ferro-manganese for the deoxidation of the metal; in a given case it may be possible to get such a good reaction in the ladle that practically all the oxides formed are absorbed by the slag. If, however, the pig iron is only slightly different, with respect to the amounts of silicon, manganese, etc., which it contains, the condition may be so completely changed that the slag in the ladle is unable to absorb the oxides from the steel, and this will naturally result in more or less trouble all through the further treatment of the steel, although the chemical composition and structure of the ingot may not be abnormal.

Mr. J. P. Snow suggested investigations of the origin of crescent breaks of rails, of which there have been a great many during the last cold winter. He distinguished two types of flaws, the one being due to gas bubbles in the ingot and the other being rolling flaws, showing cracks or folds in the surface of the ingot or bloom. He suggested that tests be made at the Watertown Arsenal to discover the origin of both kinds of flaws. In the case of low-carbon steels, holes will weld up much better during the rolling operation than in high-carbon steels, but comparatively high-carbon steel must be used for rails.

Mr. C. S. Churchill suggested that a most important subject for investigation would be the effect of different methods of rolling steel from ingot to bloom and from bloom to finished shape, like the effect of variation of reduction, variation of the number of passes and the effect of the time element.

Piping and Segregation in Steel Ingots.

Prof. Henry M. Howe's long paper, presented at a former meeting of the Institute, was the subject of considerable discussion.

A long discussion by Mr. P. H. Dudley pointed out that according to his experience the most essential thing for the production of sound ingots is to allow more time for recarburizing either in the converter or ladle before teeming. The shortening of the time in the Bessemer department from recarburizing to teeming has contributed to the inferior product of Bessemer rails in large outputs. Segregation in the long ingots, particularly with 0.1 phosphorus, is a serious thing for

modern high-speed traction. But with respect to wear, high-carbon low-phosphorus rails are a good deal better. Basic open-hearth steel, in the manufacture of which proper time is allowed for the escape of the oxidation products, has proven exceptionally tough and free from oxides and included slag. Its rate of wear seems to be slow and it seems to offer high safety in sections as girders.

Mr. Dudley mentioned 95-pound rails high in carbon and low in phosphorus, made from 14-inch ingots in 1891 and 1892, most of which are still in the track. In making them, after carburization in the converter, the metal was poured and remained in the ladle 5 to 6 minutes, to allow the chemical reaction to go on and the oxides to escape before teeming; the ingots, which were stripped, were then thrown down in the pits and charged into horizontal furnaces for equalizing the heat before blooming. The blooms were cropped until sound steel was obtained, then chipped under the steam hammer, and again charged into horizontal furnaces for reheating, and finally rolled into rails in eleven passes. For finishing a temperature between 950° and 1,000° C. was used.

Mr. Dudley thinks that the marking of rails which has been practiced by some companies in the past will be required by every mill in the future. Since 1893, Scranton rails were marked A, B and C for the top, middle and bottom rails from the ingots. Imperfections were mostly found in the A rails.

Prof. H. M. Howe, in discussing the subject, did not think that large size is the chief course of segregation. Although individual cases may differ considerably, greater quantities of large and of small ingots will give about the same average in segregation.

Mr. H. W. Hixon expressed the opinion that the open-hearth process gives better rails, because the occluded gases have time to escape. With the electric furnace steel process even better results must be obtained, since there will be no occluded gases. He also suggested the use of a steel mixer, or reservoir, in which time is given to the steel to get rid of the gases before it is put into the ladle.

Dr. R. W. Raymond also referred to electric steel processes, and mentioned the remarkable high quality of the steel produced in the Héroult furnace, which he had seen in operation in Germany. He also thought that the good results obtained with this process are chiefly due to the fact that the steel remains molten long enough in the furnace to let the gases escape. Mr. A. A. Stevenson thought that segregation is of little moment if enough of the top of the ingot is discarded. Dr. Wm. Campbell emphasized that in finishing the proper temperature is of importance. The amount of reduction in the rolls also determines the properties of the product.

In the afternoon session of Feb. 19, Mr. Thomas H. Leggett presented a paper on present mining conditions on the Rand in South Africa, while Mr. T. Lane Carter spoke on the Chinese on the Rand.

Fuel Briquetting.

An interesting, brief paper by Edward W. Parker described a briquetting plant installed at the Bankhead Mines in Canada. The coal is anthracite, but more friable than Pennsylvania anthracite, so that more dust is produced. This was formerly wasted but is now utilized. The analysis of the coal is 83.5 per cent fixed carbon, 8 per cent volatile matter, 8 per cent ash and 0.5 per cent moisture. The briquetting process employs pitch as a binder, the pitch being introduced into the coal dust with the aid of an atomizer. One plant with a capacity of 10 tons per hour is in operation, while a second plant of the same size is in course of erection. Both plants when in operation will have an output of about 15,000 tons per month. The briquets sell at $4.00 per ton at the plant.

Mr. William H. Blauvelt then gave data on the Semet-Solvay briquetting plant at Detroit. Coke breeze is briquetted with pitch as a binder, but in view of the limited amount of coke breeze available some anthracite is mixed with it. Since the briquets are sold in competition with anthracite, freedom from smoke is a requirement. Mr. Blauvelt sketched the results of briquetting methods in making commercially useful the lignites and semi-lignites of the Far West. For steam raising large briquets are preferable, while for use as fuel in houses small briquets are more desirable. There are now seven plants in operation for the making of such small briquets. The total cost of briquet making, including both the cost of the briquetting operation and the cost of the pitch, ranges from $1 to $1.60 per ton.

Dr. James Douglas referred to the difficulty of tar not being available everywhere. Mr. Blauvelt, in discussing the possibilities of by-product coke ovens in the West, said that there would be no difficulty to sell coke in the West but in selling tar. Dr. Douglas thought that the tar could be sold to the railroads, but he questioned whether there would be a market for the ammonium sulphate in the West, since our Western farmers are not yet acquainted with artificial fertilizers.

Mr. N. Lilienberg discussed the artificial compression of semi-liquid steel ingots in the special apparatus which he has devised for this purpose, and by means of paraffine ingots he showed what results can be obtained.

At the evening session of Feb. 19, Dr. Joseph A. Holmes gave data on recent coal mine disasters in this country. Feb. 20 and 21 were devoted to various excursions.

Western Association of Technical Chemists and Metallurgists.

The third general convention of this young and vigorous society, which has now some 300 members, was held in Deadwood, S. D., from Jan. 2 to 4. Papers were presented by H. W. Hardinge, on the conical tube mill; by J. M. Tippett, on cyanide clean-up at the Portland mill; by Willett Barton, on an assay scheme for cyanide solutions; by J. B. Ekley, on a new and short method for the determination of tungstic acid in wolframite ores; by G. A. Burrell, on the calorific value of coal as determined by the Mahler bomb calorimeter; by J. M. McClave, on tabling roasted ores, and by M. F. Coolbaugh, on a new method for the determination of arsenic. Various very instructive excursions were made to cyanide works at Deadwood, Lead and Pluma. A South Dakota section of the association has been organized.

Society of Chemical Industry.

At the meeting of the New York Section of the Society of Chemical Industry, held on Feb. 14 at the Chemists' Club, Dr. Charles Baskerville presented a very suggestive paper on the injury to vegetation by the fumes from chemical factories. One particularly interesting point brought out at the conclusion of the paper was the enormous amount of sulphur dioxide set free in the atmosphere of a city like New York during a year from the burning of coal for heating purposes. Figures were given of air analysis at various points in New York City. Since electric heating is practically out of question, there seems no other possible remedy but burning producer gas for heating purposes.

Mr. E. A. Sperry spoke on the preparation and uses of anhydrous tetrachloride of tin. As well known from various recent patents of Mr. Sperry, he has been much interested in detinning by means of chlorine for the production of tin tetrachloride. Mr. Sperry remarked in his paper that *anhydrous* tin tetrachloride has been heretofore a scientific curiosity, but that the anhydrous liquid (as made by a distillation process) will be, in his opinion, the form in which tin tetrachloride will be used in future.

Dr. Maximilian Toch finally spoke on the influence of sunlight on paints and varnishes. In this paper the distinguished paint chemist gave for the first time some of the results of

his researches of many years to the public. All three papers were discussed at some length.

After the conclusion of the meeting of the Society of Chemical Industry the annual meeting of the Verein Deutscher Chemiker, with election of members, was held.

American Electrochemical Society.

The annual spring meeting of the American Electrochemical Society will be held in Albany, N. Y., on April 30, May 1 and 2 (Thursday, Friday and Saturday). The proximity of Troy, Schenectady and important water-power plants will lend interest to excursions in connection with the meeting. We will publish the program of the meeting in our next issue.

At the meeting of the Board of Directors, held in Philadelphia on Jan. 28, the following gentlemen were elected members: J. Robert McFarlin, Electric Service Supplies Co., Keokuk, Ia.; James Aston, Thos. Aston & Son, Milwaukee, Wis.; George E. Lond, University of Wisconsin, Madison, Wis.; Rudolf Albrecht, the Sun Co., Marcus Hook, Pa.; George R. Kendall, McGill University College, Vancouver, B. C.; Edward Zaremba, American Foundry & Machine Co., Chicago, Ill.; Otto Mantius, American Foundry & Machine Co., Chicago, Ill.; Johan Fr. Irgens, Technisk Bureau, Ltd., Bergen, Norway; Walter H. Aldridge, Canadian Pacific Railway, Trail, British Columbia.

At the meeting of the Board of Directors, held in New York City on Feb. 29, the following gentlemen were elected members: Herbert C. Jennison, Coe Brass Manufacturing Co., Ansonia, Conn.; Percy A. Boeck, Norton Emery Co., Worcester, Mass.; William C. Marti, University of Illinois, Urbana, Ill.

The First Mendelejeff Congress.

The first Russian Mendelejeff Congress, in which both chemists and physicists participated, was held in January in St. Petersburg, in honor of the memory of the late D. Mendelejeff. For the following report we are obliged to Prof. Alexander Krakau, of the Electrotechnical Institute of the Emperor Alexander III., at St. Petersburg.

The Congress was opened on Jan. 2, 1908, by Prof. I. Borgman, chairman of the executive committee and president of the University of St. Petersburg, who reported on the organization of the Congress, and proposed Prof. N. Beketoff, the oldest of the Russian chemists and a member of the Russian Academy of Science, as chairman of the Congress. The motion was carried with great enthusiasm.

Three sessions of the Congress were devoted wholly to the memory of Mendelejeff. During the first of these (Jan. 2) numerous messages of congratulation were received from various municipal and educational institutions and societies, etc., and papers were presented by Prof. W. Tischenko, on the life of Mendelejeff; by Prof. V. Kurbatoff, on the scientific work of Mendelejeff, and by Prof. N. Beketoff, on the importance of the periodical system.

In the second session (Jan. 5) Prof. G. Gustavson spoke on Mendelejeff and organic chemistry; Prof. P. Walden, on the work of Mendelejeff on solutions; Prof. B. Weinberg, on the work of Mendelejeff on Capillarity and "the temperature of the absolute boiling point"; Prof. F. Kapustine, on the work of Mendelejeff on the variations of volume of gases and liquids, and Prof. G. Jukowsky, on Mendelejeff's investigations of the mechanical resistance of liquids and aerial locomotion.

In the third session (Jan. 12) Prof. A. Wojeikoff discussed Mendelejeff's researches in meteorology; Prof. K. Harychkoff, the work of Mendelejeff on Russian and American naphtha and its industry; Prof. P. Rubzoff, Mendelejeff's investigations on explosive substances, and Prof. N. Yegoroff, the work of Mendelejeff on the standards of weights and on precise measurements in general.

In the intervals between these solemn sessions other meetings were held under the auspices of the different sections into which the Congress was divided, according to its organizations, as follows:

Six joint sessions, in which papers were read on physical chemistry and others of a nature to interest both chemists and physicists.

Nine sessions of the Section of Pure and Applied Chemistry and Electrochemistry, in which seventy-seven papers were read.

Four sessions of the Section of Physics, in which twelve reports and fifteen experimental lectures were presented.

In the Section of Agricultural Chemistry twenty-three papers were read.

In the Section of Biological Chemistry thirteen papers were presented.

During one of the sessions held at the Electrochemical Institute, A. Lodyguine, honorary electrical engineer, spoke in behalf of the American Electrochemical Society, which had sent by cable its congratulations to the Congress.

The following resolutions were adopted by the Congress to honor the memory of Mendelejeff:

1. To erect a monument to Mendelejeff in front of the University of St. Petersburg, where Mendelejeff spent most of his life, and to open an international subscription for this purpose.

2. To found a "Mendelejeff Institution," which is to consist of

a. A Mendelejeff Museum of Pure and Applied Chemistry, where are also to be preserved all sorts of souvenirs of the work and private life of Mendelejeff.

b. A library and laboratories, in which scientists could make studies and investigations of a kind impossible in most laboratories.

c. A large hall, for the use of celebrated foreign scientists that would be periodically invited to deliver lectures and award the "Mendelejeff Medal."

3. To organize periodical "Mendelejeff Congresses" of chemistry and physics.

The first Congress was attended by more than a thousand members.

The second Congress will be held at St. Petersburg in January, 1909, to celebrate the seventy-fifth anniversary of the birth of Mendelejeff.

Autogenous Welding of Aluminium.

We have referred repeatedly to Mr. M. U. Schoop's method of autogenous soldering of aluminium which the inventor exhibited some time ago at his presence in New York City before the Chemists' Club.

A stock company for the exploitation of this invention has now been formed in Zurich, Switzerland, with a capital of 1,000,000 francs ($200,000). Prof. Dr. von Salis is the president and Messrs. J. H. Frey and M. U. Schoop are among the directors. It is expected that in view of the recent drop of aluminium prices in Europe the use of aluminium for manifold purposes will increase rapidly and extensively, and that the new simple process of autogenous welding of aluminium will have a bright future in this development.

From a recent paper of Mr. M. U. Schoop in the *Chemiker Zeitung* it now appears that the flux which he uses is an aqueous solution of some alkali metal chloride; for instance, a chloride of potassium sodium or lithium, but from what Mr. Schoop stated here in the Chemists' Club it may be concluded that the flux is a somewhat more complicated mixture. If the aluminium to be welded is only of moderate thickness the flux may be applied with a brush in a semi-fluid paste form. For heavier work it is more convenient to dust the flux as a dry powder along the joint to be made.

The joint thus produced is free from any foreign metal. This is of great importance for the durability of an aluminium article in water. Pure aluminium is durable in sea-water, and so are joints made by autogenous welding, as has been shown by tests extended over several months. The purity of the aluminium is therefore of great importance. An easy test to determine whether an aluminium joint contains foreign metals or not is to suspend the article in water containing some hydrochloric acid. If there is any foreign metal present a galvanic couple is established and gas bubbles appear at the joint. Of course, such a joint will not last.

The mechanical properties of autogenously welded joints of aluminium are very good, as has already been noticed in our columns. Examined under the microscope the structure of the joint is found to be the same as that of aluminium itself.

In another recent issue of the *Chemiker Zeitung*, Mr. W. C. Heraeus, of Hanau, mentions another process of his own for welding aluminium, various pieces of apparatus with welded joints having been exhibited at the Paris Exposition in 1900. He has made several pressure pots of some 400 gallons capacity out of 15-millimeter aluminium sheet welded together by his process, which have successfully withstood a pressure of 17 atmospheres.

It will be remembered from the simple experiment which Mr. Schoop showed at the Chemists' Club that the application of the process is exceedingly simple, so that it should be useful not only for welding aluminium wires for electrical purposes, but for making various aluminium apparatus, tubes, pipe, etc., for chemical works, breweries, vessels, automobiles, etc.

The Dependence of Civilization on Chemistry.

Mr. Arthur D. Little, chemical engineer, of Boston, has just been re-elected official chemist of the American Paper and Pulp Association, at the recent meeting of which he read a most interesting paper upon recent development in the manufacture of paper and pulp.

From another recent paper of Mr. Little we extract the following remarks on the dependence of our civilization on chemistry:

"Chemistry enters so intimately, even though unobtrusively, into every phase of modern life and thought that it is perhaps impossible to present in any adequate degree the real dependence of the community upon the work of chemists past and present. Industrial revolutions are seldom chronicled, and more rarely celebrated, though their influence upon the welfare of mankind may be as profound as that of other revolutions, the records of which are traced in blood. It can be no longer said, as was said to the father of chemistry as he passed out to execution, 'The public has no need of chemists.' If we were to take away what chemists have contributed, the whole structure of modern society would break down at once. Every commercial transaction in the civilized world is based upon the chemist's certificate as to the fineness of the gold which forms our ultimate measure of values. Faith may remove mountains, but modern society relies on dynamite. Without explosives our great engineering works must cease, and the Panama Canal, no less than modern warfare, become impossible.

"Prices rise and fall with the variations in the gold supply as the barometer responds to the changing pressure of the atmosphere, so that to the cyanide and chlorination processes which have so greatly increased the world's supply of gold, must be ascribed a potent influence on market prices everywhere. With the development of the steel industry have come great fortunes and greater corporations, bringing with them social benefits and social problems hitherto unknown. This industry rests pre-eminently upon the work of chemists, as its greatest master has been quick to testify, and is to-day at every point under the strictest chemical control. The Bessemer process alone was estimated by Abraham S. Hewitt to add directly and indirectly $2,000,000,000 yearly to the world's wealth. Of this vast sum Bessemer himself retained in all about $10,000,000 dollars, or one-half of 1 per cent of his contribution to the community in a single year. And this is characteristic generally of the rewards which come to chemists. They are not taken from the common fund, no man is poorer for them, their recipient has made others richer in those rare cases in which he has become rich himself."

Detinning Suit.

Before Hon. James E. Howell, vice-chancellor, the suit in equity brought by the firm of Th. Goldschmidt, of Essen, Germany, against the Vulcan Detinning Co. was continued on Feb. 24 and the following days. As noticed before in these columns, the complainants ask the court to restrain the Vulcan Detinning Co. from using Dr. Hans Goldschmidt's process of detinning and for an accounting. (Concerning the history of the whole complicated litigation on electrolytic detinning, see our Vol. IV., p. 46; our Vol. V., p. 345, and this year's January issue, p. 225.)

The first witness was Mr. Samuel R. Beardsley, president of the Vulcan Detinning Co., who testified that in 1898 he and his associates sent A. Kern, of A. Kern & Co., to Europe to buy the secret process of detinning, and that Kern went abroad and purchased it from Laernos (the detinning plant in Vliessingen, Holland), who subsequently came to the United States, and with the aid of one Zeyen (formerly in the employ of Th. Goldschmidt, and now in the employ of the Vulcan Detinning Co.) constructed the detinning plants at Sewarren, N. J., and Streator, Ill., now operated by the Vulcan Detinning Co.

The complainants, Th. Goldschmidt, of Essen, claim that Kern, when he purchased the process from Laernos, knew that the process had been stolen from them (Goldschmidt) in the way described in Vice-Chancellor Bergen's former decision, abstracted at length in our Vol. IV., p. 46.

Considerable testimony was taken before the court as to the process, but this was taken in secret, so that the process itself will not be disclosed to the public. The firm of Th. Goldschmidt is represented in court by Mr. R. V. Lindabury and Mr. Halsey M. Barrett, of the New Jersey bar, and Mr. Hubert E. Rogers, of the New York bar. The Vulcan Detinning Co. is represented by Mr. Robert H. McCarter, of the New Jersey bar, and Mr. Henry Wollman, of the New York bar. The case is not yet concluded.

In this connection it may be interesting to note that the firm of Th. Goldschmidt intend to shortly begin detinning in this country.

CORRESPONDENCE

The Removal of Sulphur in the Electric Induction Furnace.

To the Editor of Electrochemical and Metallurgical Industry:

Sir:—With respect to the note on Mr. A. Schmid's article on the removal of sulphur in the electric induction furnace (your February issue, p. 81), I beg to make the following remarks:

I have found considerable reaction on heating sulphides and silicides together. When iron, containing a high content of sulphur and silicon, is heated to the high temperature existing in electric furnaces, the silicon and sulphur react. Gaseous (at that temperature) silicon sulphide is evolved. It can be easily caught and identified as such or can be absorbed by having calcium silicide in contact with the electrically heated iron. This calcium silicide, when cold, liberates sulphuretted hydrogen in contact with water.

Max Haff.

Ottawa, Can.

Electric-Furnace Reactions Under High Pressure.

An account of a very extended investigation by Dr. R. S. HUTTON and Mr. J. E. PETAVEL, on electric-furnace reactions under high gaseous pressures, was presented in a paper last year before the Royal Society of London. The full account may be found in the Philosophical Transactions of this Society, series A. Vol. 207, pp. 421 to 462 (A. 423, Jan. 17, 1908).

High-Pressure Furnace.

The authors first give a full account of their high-pressure furnace (which was already briefly noticed and illustrated

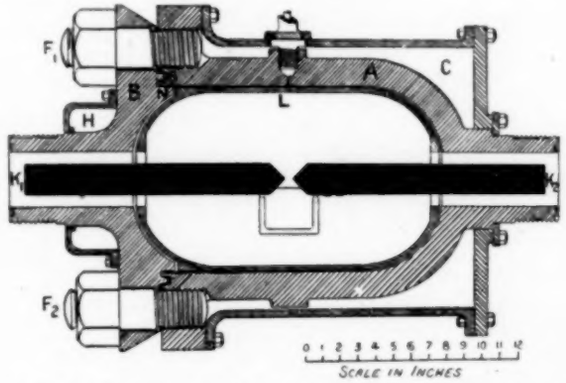


FIG. 1.—SECTIONAL DRAWING OF HIGH-PRESSURE FURNACE.

in our Vol. I., p. 244). It is capable of employment as resistance or arc furnace in various ways and may be used to pressures as high as 200 atmospheres. A large steel enclosure of about 20 liters capacity was designed, so that within the shell many different forms of furnace, such as arc or resistance furnaces, could be built up. The furnace may be used either in a horizontal or vertical position to suit different requirements.

The construction of the enclosure will be easily understood by reference to Figs. 1 and 2, giving sectional drawings. The shape of the interior is cylindrical, 10 inches diameter by 17 inches long, with hemispherical ends, one of which forms the cover B, and is held in place by ten 2¼-inch studs (F_1F_2), which are fixed into a flange of the main forging A. The cover is rendered gas-tight by a spigot joint S, packed with lead; it is surmounted by a cast-iron casing H, through which cooling water is circulated.

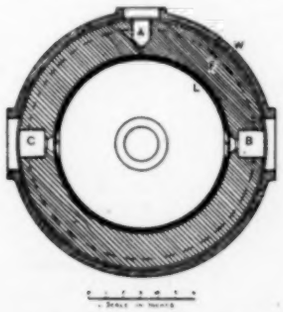


FIG. 2.—TRANSVERSE SECTION THROUGH THE CENTER OF HIGH-PRESSURE FURNACE.

The main forging A is surrounded by the cast-iron water jacket C. The main forging A has a ruling thickness of 1½ inches, which is increased to 2 inches over central belt, through which the various openings are bored. The lead joint S above referred to consists of a lead ring placed in the spigot groove S. The projection N protects the joint from contact with the hot gases when the furnace is in use and shields it from mechanical injury when the cover is being lifted or replaced.

Both the hemispherical ends of the furnace have projections K_1K_2 bored out to a distance of 3 inches. The carbon holders which move in these recesses are thus protected from the direct heat or flame of the furnace. The length of the projections K_1K_2 is sufficient to allow a feed of 8 inches. To obviate any risk of damage to the main forging by contact with the hot furnace materials, a cast-iron lining L was always used.

When in a horizontal position the furnace rests on four cast-iron feet, as shown in Fig. 3. When vertical (Fig. 4) it is supported by the cover of the water jacket, the lower carbon feeder passing through a hole cut in a massive wooden stand.

The main forging is provided with three openings, as shown in Fig. 2, which is a section through the center of the furnace perpendicular to the axis of the carbons.

The aperture A serves to receive the valve through which the enclosure is filled with compressed gas, whereas in most cases one of the windows shown in Fig. 4 is screwed into B. The third opening is connected to a pressure gauge, and serves, also, when desired, for the escape of the gaseous products of reaction. W is the water jacket, F the main forging and L the cast-iron lining.

The carbon-feeding mechanism is shown in detail in Fig. 5. A ring B is fitted to each of the projections K of the furnace. To this ring the small cover A is bolted. The joint is made, as in the case of the main furnace cover, by means of the lead-packed spigot V. The cover carries two columns C_1C_2 surmounted by a yoke Y, which is insulated from them by micanite bushes and washers R. To this yoke the main terminals (not shown in the figure) are fixed. The nut N is

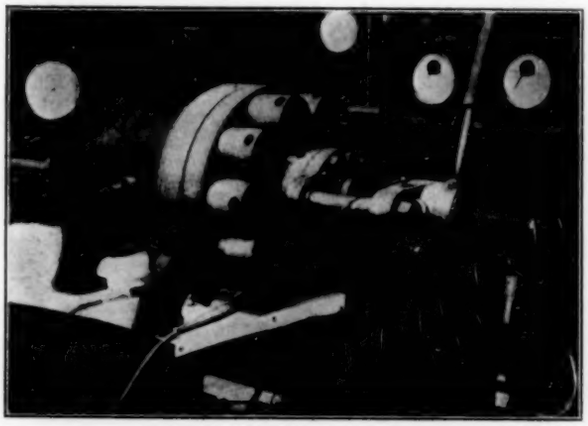


FIG. 3.—HIGH-PRESSURE FURNACE (HORIZONTAL POSITION).

revolved by means of steel levers inserted in the holes T, and thus the feeding rod S is moved forward. The feather F fits in a groove cut in this rod and prevents it following the rotary motion of the nut.

The feeding rod passes into the furnace through the insulated stuffing-box P. This stuffing-box serves the double purpose of making a gas-tight joint and providing insulation sufficiently perfect for the relatively low e. m. f. which is generally required with this furnace. As packing a mixture of asbestos and tallow is used, which in itself assists the insulation. The stuffing-box is compressed by means of the ring D, which presses on the gland Q, but is electrically insulated from it by mica washers and bushes. The inner gland is insulated in a similar manner from the steel cover.

The feeding rod is hollow. The current of water passes into it at I, and flowing through an inner brass tube is delivered at the extremity of the rod and passes back to the outlet O. A gas connection G is also provided, by means of which compressed gas can, when necessary, be passed directly into the center of the furnace through the axis of a hollow electrode M.

Two different patterns of carbon holders are used by the authors. Carbons of 30 millimeters diameter or less are held by clamps. The larger carbons are electro-coppered at their ends, and soldered into cup-shaped holders, as shown at H (Fig. 5). The lip of the cup is fitted with a ring of refractory insulating material U, which nearly fits the bore of the

tube K, and thus protects the stuffing-box from flame and dust.

Although unnecessary for the purely chemical work, it may be desired to observe or photograph the arc or its spectrum under conditions of high pressure. For this purpose windows are inserted in the openings P and C of Fig. 2.

The forms of construction are shown in Fig. 6. The window itself consists of a glass or quartz cone W, ¾ inch thick and ½ inch diameter at its smaller end. This transparent cone is forced into the gunmetal fitting after being surrounded with a thin film of cement, and is held in place by a metal ring, the shape of the glass tending to make the joint more perfect the higher the pressure.

The joint between the fitting and the aperture in the main forging is made by the ring *a* turned on the end of the fitting, which presses tightly against a steel ledge, no packing being required. The joint between the fitting and the water jacket is made by means of a gunmetal ring R, which screws onto the fitting itself.

The two types of window differ only in the relative position

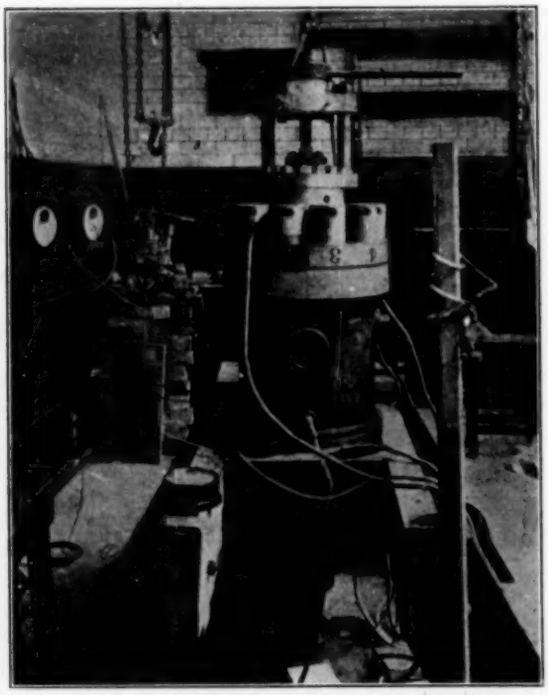


FIG. 4.—HIGH-PRESSURE FURNACE (VERTICAL POSITION).

of the transparent plug. The design shown at A gives a clearer view of the arc, but for very large currents it is advisable to make use of the fitting B, in which the glass plug is more carefully protected from the source of heat.

Throughout the work no difficulty has been experienced in keeping the furnace gas tight. It is, of course, equally suitable for use as a vacuum furnace and has been occasionally employed in this way, in connection, for instance, with spectroscopic investigations.

For high-tension currents up to 25 000 volts, the authors employed a smaller furnace, for the description of which the readers must be referred to the complete paper. As to the preparation, a compression of gases, reference should be had to the authors' former paper in our Vol. II., p. 139.

The Behavior of the Electric Arc Under Pressures.

When the arc is started in a compressed oxidizing atmosphere, the current is at first unsteady and the electrodes must be rapidly fed up. Soon, however, a steadier state is reached. If, after such a run, the furnace is opened and the carbons examined, it will be observed that by the action of the current the electrodes have been so shaped as to nest one into the other. In this way a considerable cross-sectional area is produced, over which the discharge can occur.

The e. m. f. of the arc rises as the presence of the surrounding atmosphere increases, and at the high pressures used in the course of this work it becomes more than double the normal value. It is, however, the first few atmospheres which produce the greatest effect upon the voltage.

An interesting effect is throughout noticeable. Although the

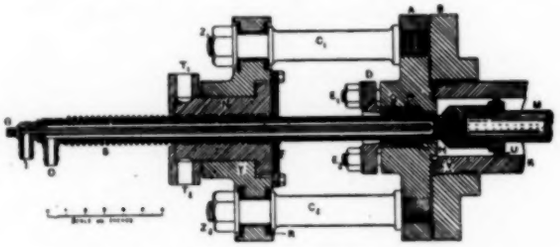


FIG. 5.—CARBON-FEEDING MECHANISM.

maximum length of arc is so much reduced, the voltage is in all cases abnormally high, and consequently a large amount of power is concentrated in a small space.

Two very distinct types of arc exist. The most usual in these enclosed furnaces is found with a non-oxidizing atmosphere, such as carbon monoxide or nitrogen. In such arcs at ordinary current densities the electrical conditions are complicated by the rapid growth of a deposit of carbon, chiefly around the negative electrode and often completely enclosing the end of the positive electrode. The difference between a resistance and an arc is then less marked. The arc flame is not visible, but is replaced by a zone of brightly incandescent carbon; electrically the conditions are ill-defined and difficult to reproduce. With an exceptionally high current density the arc in a non-oxidizing gas at high pressure gives a well-defined flame.

An entirely different type is obtained in an oxidizing atmosphere, and in this case alone are the results comparable with the well-known conditions of the ordinary open arc. The arc

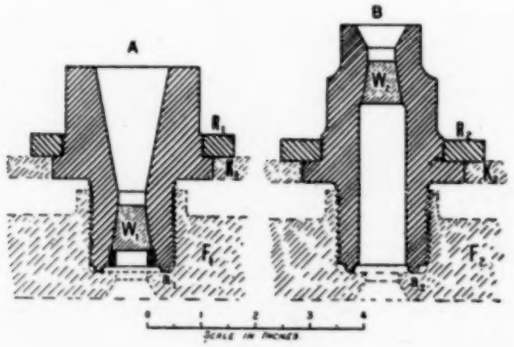


FIG. 6.—WINDOWS.

then shows a bright flame, which, if the electrodes are fed up rapidly and with regularity, can be easily maintained. Here again the increased voltage observed is due principally, as shown by other experiments, to the first 10 or 15 atmospheres.

A noticeable feature in all the experiments carried out in air is the very rapid rate of burning of the electrodes.

To take one instance: with 27 millimeter carbons and a 30-amp. arc under a pressure of 29 atmospheres the carbon was consumed at a rate of about 6 millimeters per minute, which is nearly twenty times as fast as at ordinary pressures. This burning is principally limited to the positive electrode. With very high-current densities the combustion becomes very violent. The oxygen thus becomes rapidly exhausted and the subsequent feeding required is relatively very small.

At first carbonic acid is formed, which is in turn reduced to carbon monoxide. This reduction occurs also when the arc is run in an atmosphere of compressed carbonic acid. In the latter case an interesting observation is the separation of flocculent carbon, which is seen to be moving rapidly in the convection currents. This phenomenon is observed from the commencement of the experiment.

The decomposition of the carbonic acid under these conditions is comparatively slow, in one experiment less than half being decomposed by the end of half an hour. A somewhat similar process goes on also in non-oxidizing gases. Finely divided carbon is deposited in considerable quantities on the cool walls of the enclosure, the weight collected being in fair agreement with the loss from the electrodes. With such gases the atmosphere, however, remains perfectly clear.

Different High-Pressure Reactions.

The first application of their furnace, made by Messrs. Hutton and Petavel, has been the investigation of the effect of high gaseous pressure upon the more characteristic and better-known electric furnace reactions. The first reaction investigated by them is the formation of **calcium carbide.** For this purpose the furnace is used in a vertical position, a layer of powdered retort carbon on the bottom of the furnace constituting the lower electrode. A mixture of lime and carbon (about 10 kg.) is filled up around a paper tube, which serves to keep a central passage free for the upper electrode. After closing the furnace the arc is started by lowering the upper electrode, which then makes contact with a carbon bed beneath it. The reaction then starts.

As it proceeds, the pressure in the furnace, due to the evolution of carbon monoxide, rises rapidly and the fused carbide collects upon the bed of carbon and soon accumulates sufficiently to come in contact with the end of the electrode. The sharp drop of the e. m. f. thus produced serves to indicate that the time has arrived to raise the carbon slightly. There is no difficulty in maintaining the smothered arc even at the highest pressures, and the regulation of the power is quite a simple matter. Currents of some 500 amps. have frequently been employed in the course of this work and maintained as long as desired.

While with ordinary atmospheric pressure the upward rush of the gases through the finely divided charge is liable to cause a considerable displacement of the charge, this is not the case at high pressures, since the gaseous products of reaction rise at a relatively slow speed and percolate through the mixture without disturbing it. On the other hand, if the furnace is used as a vacuum furnace, the projection of the charge is very marked and causes considerable trouble.

An extremely low consumption of the carbon electrodes is characteristic of the high-pressure process, the consumption being so small as to be hardly appreciable.

The authors have carried out a long series of experiments, especially to study effect of carbon monoxide upon the yield. They conclude that, "however contradictory it may seem, even a concentrated and compressed atmosphere of carbon monoxide has no deleterious effect upon the formation of calcium carbide. The influence of pressure *per se* has not resulted in any marked change in the chemical or physical nature of the products, neither can a considerable decrease in the yield be traced to this cause. Such variations in the purity of richness of the carbide as have been noticed are attributable only indirectly to pressure, being accounted for by the increased thermal losses in high-pressure gases."

The next process to which the authors have employed their high-pressure furnace is the **fusion of silica,** in the hope to obtain a greater fluidity of the silica, resulting in freedom of the final product from occluded gas bubbles. However, these experiments though they have been modified in various directions, have not resulted in the production of transparent fused quartz free from bubbles.

The authors have then studied the formation of **carborundum** under high pressure, the pressure being allowed to rise up to 100 atmospheres.

"There is little doubt that the production of carborundum is the result of the interaction of the vapor of silica and the highly-heated granular carbon. From the previous work on quartz we were therefore led to anticipate that under pressure the reaction would not occur very rapidly.

"Several experiments confirmed this impression. An examination of the furnace after the run showed, in every case, that, though the mixture of sand and carbon had attained a sufficiently high temperature to effect the fusion of the quartz to a considerable depth, thus agglomerating the mixture, only a small quantity of carborundum was formed, and that immediately around the central core.

"Another distinctive feature of the pressure experiments is the almost entire absence of the amorphous variety of carborundum. The reaction progresses at a slow rate, but apparently uniformly, the resulting pressure being, as in the case of calcium carbide, a linear function of the time."

The last investigation of the authors refers to the **direct reduction of alumina by carbon.** Since a successful solution of this problem would be of great importance we give this part of the paper in full elsewhere in this issue.

The whole investigation was carried out with the aid of funds awarded by the Government Grant Committee of the (London) Royal Society, in the Physical Laboratory of Manchester University.

A Review of the Zinc Industry.

BY H. M. BURKEY.

The zinc industry during the year 1907 kept abreast with business in general. The smelting capacity was increased by the completion of several new plants, the construction of which was started either in 1906 or early in 1907, when there was a fair margin between the price of the ore and that of spelter.

In the last quarter of 1907, the general falling off in business also reflected on the zinc industry. The drop in the price of spelter caused many mines with high cost of operations to shut down, resulting in a scarcity of ore, which, combined with the low price for spelter, made smelting unprofitable, so that many furnaces were put on dead fire or shut down altogether.

At present, the state of the zinc industry is briefly as follows:—

ORES.

The problem of milling complex sulphides with a high recovery of the zinc content, as well as of the other metallic constituents, still presents a problem for a satisfactory solution. The present method of smelting requires a comparatively pure material to work on. It must not contain impurities to contaminate the spelter nor substances that will attack the retorts. Besides, if the ore be a sulphide, it must be roasted to a low sulphur content so as not to hold back too much zinc in the smelting operation. To avoid these difficulties in milling, there is at present a tendency to develop processes which will treat sulphides directly for the recovery of all metals contained therein, or after they have been roasted to about 5 per cent sulphur. Such processes as Imbert's and Rice's may be mentioned to illustrate the former and those of Snyder and Johnson the latter method. The advantages from such a process, if commercially successful, are many, and it is therefore not surprising that many efforts are bent in this direction.

Magnetic separation, either of the crude or of the partly roasted sulphides, still holds its position in the milling of zinc ores.

The best-known electro-magnetic separators are the Wetherill, the Dings, the Cleveland-Knowles and the International. Of these, only the Wetherill is used for the separation of

crude sulphides. No other commercial machine has made its appearance during the year. Of the electro-static separators, the Blake-Morscher machine is the only one used in this country. At the Colorado Zinc Company, supplementary to the Wetherill, it separates resin blende, which is non-magnetic, from pyrites. An electrostatic machine of a different make is said to be used successfully in Mexico. For giving an ore containing blende and pyrites a magnetic roast, to make the pyrites magnetic, A. R. Wilfley (United States Patent No. 859,420 of July 9, 1907, Electrochem. & Met. Ind., vol. V., p. 330) has designed a furnace wherein the ores travel downward with a current of combustion gases and air. At the bottom of the furnace they come in contact with a water-cooled plate whereby they are cooled to a temperature below that of roasting, and then carried out of the furnace. This type of furnace has been installed by the Summit Mining & Smelting Co., at Kokomo, Colorado, the Colorado Zinc Co. at Denver, and the Empire Zinc Co. at Canon City, Colorado.

A series of experiments was, in 1897, carried on by Dr. F. Esser ("Metallurgie," 1907, p. 592 and p. 607; Electrochem. & Met. Ind., vol. V., p. 469), on mixtures of blende and other minerals on an electric separator. The results obtained show that electristatic separation is only successful on particles within certain sizes. Particles of 1 mm. or less gave the best results. A very fine powder was not suitable. Impregnation of foreign material acts as a disturbing factor and conditions are more favorable at places high above the sea level, which, as a rule, have a dry climate.

Much had been said about the flotation processes in the past, but of late little is heard of them. Experimentally, they proved very efficient but their success on a commercial scale is not so evident. During the year, the following three new flotation processes have received attention:

The Elmore Vacuum Oil Process depends, not only on the oil and acid added to give buoyancy to the metallic particles, but also on the air in the water drawn out by the vacuum. This process is carried out in a machine which is automatic and continuous and the consumption of acid and oil as well as the power required is said to be low. On Broken Hill tailings over 95 per cent of the zinc content has been extracted.

D. Norris (United States Patent 864,856 of Sept. 3, 1907 and 873,586 of Dec. 10, 1907) points to the fact that at high altitudes water does not contain enough air to float the particles in the vacuum process and he, therefore, proposes to supply air under pressure. This process has not yet been tried on a working scale.

The tube process of Macquisten (United States Patent No. 865,194 of Sept. 3, 1907, and 865,195 of Sept. 3, 1907) works on a different principle from the other flotation processes, as it does not use any oil or acid. It relies on the fact that sulphides do not penetrate the thin film on the surface of water, while the gangue does. This process is also automatic and continuous. At the Atlantic Cable Mine, Rico, Colorado, a concentrate containing 7.78 per cent Pb. and 41.2 per cent Zn. was made from an ore assaying 3.94 per cent Pb. and 19.19 per cent Zn. (Eng. & Min. Jour., October 26, 1907).

Roasting.

Of the mechanical reverberatory kilns the Zellweger is now the favorite, while the Hegeler type of roasting furnace is used where the gas is to be converted into sulphuric acid. The Pennsylvania Salt Manufacturing Co. has put the Wedge furnace, a McDougal type, on the market. The large sizes in which this roaster is made and the large-sized central shaft which allows a man to enter, making thus all parts of the furnace accessible, are a decided advantage. During the year, quite a little attention was given to the cooling arrangement of shafts and arms as well as to a removable rabble, as is shown by the following United States Patents:

Klepetko, No. 843,825 of February 12, 1907;
Rankin, No. 863,045 of August 13, 1907;
Kirk, No. 863,187 of August 13, 1907;
Leggo, No. 872,827 of December 3, 1907, and
Shipley, No. 873,687 of December 10, 1907.

Smelting.

Of the patents granted on furnaces, the following may be mentioned: Lanyon (United States Patent 839,160 of Dec. 25, 1906; Electrochem. & Met. Ind., vol. V., p. 64) arranges his furnace so as to give a gradual and perfect combustion of the fuel. Fuel and air are admitted at the bottom of the furnace where ignition starts, the hot gases pass upwards around the retorts, meeting more air of combustion from openings in the sides, then strike the arch of the roof, thereby being deflected downwards, and pass out through openings in the bottom. This arrangement makes possible a very perfect combustion, which is easily regulated.

A. Desgraz and P. Schmidt (United States Patent 843,872 of Febr. 2, 1907; Electrochem. & Met. Ind., vol. V., p. 97) aim to obtain in a distillation furnace a uniform temperature throughout the furnace in the heating from the initial temperature to that required at the end by placing tows of retorts on each side of a combustion chamber into which gas and air are admitted through ports in the bottom. The supply of gas and air can be regulated from the outside to give the desired results.

A lining for retorts composed of two layers is made, according to F. B. Smith and G. C. Glynn (United States Patent No. 860,701 of July 23, 1907) from two coats applied to the inside of the retort. The first solution is one of aluminium and magnesium sulphates, into which an easily fusible compound of an alkaline earth metal, such as calcium fluoride, has been thoroughly mixed. The second coat is made by mixing carborundum in a solution of chromic acid. The action on application of heat is said to be as follows: Aluminum and magnesium sulphates break down to their oxides, the sulphuric acid set free combines with the calcium fluoride, forming an enamel which is claimed to become very hard. Results recently obtained on Joplin ores show a saving in retort fuel and a higher recovery in spelter over the ordinary method (private communication).

For obtaining the intimately mixed charge of ore and reducing carbon, so necessary for good results, concrete mixers, such as the Ransone, are being used. A Vapart mill is used by the Bartlesville Zinc Co., the United Zinc & Chemical Co. and the United States Zinc Co. at Pueblo, for this purpose.

James (United States Patent No. 851,668 of April 30, 1907) and Kirk (United States Patent 847,074 of May 18, 1907) have invented devices for mechanical charging of retorts. They both use the same principle, viz.: the injector-like action of a jet of a medium under pressure. This medium can be either steam or air.

For making clay condensers, the newer smelters have installed the Vanatta machine (United States Patent 832,177 of October 2, 1906).

Special processes which have been brought out recently are those of De Laval, Imbert and Rice.

De Laval (United States Patent 852,440 of May 7, 1907; Electrochem. & Met. Ind., vol. V., p. 241, where the furnace is illustrated), subjects the ore and reducing material to a rapidly rotating gas or air current in a vertical cylindrical furnace and the chemical reactions occur in the rotating mass. Slag and unreduced ore stay near the sides of the furnace and are collected and drawn off at the bottom, the gases and vapor escape through a central opening in the bottom to a condenser. When a sulphide ore is being reduced, the charge will consist of ore, iron ore and carbon, the gas, CO or the proper amount of air to form CO gas; when oxides are used, carbon is only added, and the gas may be either CO or air; and when zinc oxide is to be produced, carbon is added and air is blown in. The large amount of gas that would have to be used is a feature that does not argue well for the process, because the

resulting vapor would necessarily be diluted to a great extent and blue powder or zinc dust is likely to result instead of metallic zinc.

What is known as the "Precipitation Process" forms the subject of Imbert's inventions (United States Patents Nos. 875,578, 875,579 and 875,580 of December 31, 1907). The ores, which can be either sulphides or oxidized ores, are dissolved in a fused bath, to which a metallic reagent, such as iron or copper, is added, thus precipitating the zinc as vapor and lead, if present, as metallic lead. The solution for sulphides may consist of a metallic oxide and metallic earth oxide or a metallic oxide and metallic sulphide, while for oxidized ores it will be a fused bath of metallic oxide and a metallic sulphide.

Rice's process (United States Patent No. 875,381 of December 31, 1907) also belongs to this class. Crushed sulphide ore mixed with about 50 per cent of finely divided iron is heated in a crucible. The volatilizing metals pass to a series of condensers and are recovered separately by regulating the temperature of the condensers. Non-volatile metals remain in the crucible in form of a matte.

THERMOELECTRIC SMELTING.

The thermoelectric smelting of zinc ores offers great possibilities. The processes can generally be made continuous and produce gases rich in zinc vapor. However, cheap electrical power must be at the disposal of the smelter, and besides many difficulties must be overcome. One of these is the condensation of large quantities of vapor to metallic zinc and not to zinc dust. Johnson (United States Patent No. 851,520 of April 25, 1907) has designed a condenser to overcome this difficulty. It is constructed of refractory material provided with baffle walls, thus giving the gases a tortuous path and a water-cooled metallic plate bottom protected from the action of the gas by a layer of molten zinc.

Johnson (United States Patent No. 868,345 of October 15, 1907; ELECTROCHEM. & MET. IND., vol. V., p. 470) proposes to smelt ores with a high iron contents by first roasting to zinc oxide and iron oxide, leaving about 3 per cent S. in the ores, mixing with reducing coal, heating in an electric resistance furnace to about 900 deg. C., thereby reducing the iron oxide to iron sponge continuing the heating until a temperature of about 1,100 deg. C. is reached, when the zinc oxide is reduced and the iron reduces any sulphide of zinc, lead and copper present. The advantages claimed are that the roaster gases, richer in sulphur, are produced and less electrical energy is consumed by bringing about the reduction of iron and zinc in successive steps; besides, the zinc vapor is not diluted.

Other electric processes are those of:

Taylor, United States Patent No. 843,777 and 843,776, of February 12, 1907; Petersson, United States Patent No. 858,621 and 858,622, of July 2, 1907; Snyder, United States Patent No. 859,132, 859,133, 859,134, 859,125, 859,136 and 859,137, of July 2, 1907; and McLoughlin, United States Patent No. 874,527, of December 24, 1907. See ELECTROCHEM. & MET. IND., vol. V., pp. 103, 228 (Taylor), p. 377 (Petersson) and p. 323 (Snyder).

Of these, it is known that Snyder has been experimenting for some time at Vancouver, B. C. (Report of Commission to Investigate Zinc Resources of British Columbia), and a furnace having a capacity of 10 tons has been built at Nelson, B. C. (*Mineral Industry* for 1906.) Also that the Canadian Zinc Company will start electric smelting in February of this year. (*Mining and Scientific Press*, of January 11, 1908.) In a paper recently read before the Tristate Mining Association (ELECTROCHEM. & MET. IND., vol. V., p. 489), Snyder claims a total saving of $10.00 per ton over the retort plant.

LIXIVIATION.

Many attempts have been made to treat complexed ores by dissolving them in solutions, then recovering the metals by depositing some other metal or by the electric current. The main object is to get the ore in solution and for its accomplishment United States Letters Patents have been granted to Baker and Burwell (No. 841,102 of January 5, 1907); Baker and Smith (No. 843,986 of February 12, 1907); Fronck (840,868 of March 5, 1907); Angell (No. 851,639 of April 30, 1907); MacIvor (No. 863,411 of August 13, 1907) and Gilles (No. 875,424 and 875,425 of December 31, 1907), and others. An account of Baker's endeavors in this field is given in an American Electro-chemical Society paper (ELECTROCHEM. & MET. IND., vol. V., p. 448).

A process for utilizing zinc sal-ammoniac skimming from the galvanizing industry has been invented by B. Terne (United States Patent No. 869,750 of October 29th, 1907). The skimmings are ground under hot water, the insoluble matter treated for metallic zinc, and the solution for zinc oxide and sal-ammoniac. This process has been worked on a practical scale.

ZINC OXIDE.

To overcome the injurious effects of the volatile matter of bituminous coal in the Wetherill process of manufacturing zinc white and at the same time make use of an ore containing lead, W. F. Gordon (*Eng. & Min. Jour.*, Jan. 5, 1907, p. 1,032), has developed a process which is in practical use at Coffeyville, Kan. The ores, after roasting, are burned in a furnace similar to the Wetherill, the zinc and lead are volatilized, the former is recovered as oxide, while the lead combines with sulphur, enough being left in the ore for this purpose, forming a basic lead sulphate.

The Tri-Bullion Smelting and Refining Company are said to have prepared plans for a large pigment plant near Canon City, Colorado, to treat the lead-zinc ores from the Kelly Mines of New Mexico.

An electrolytic process of making lithopone has been invented by J. B. Candau and A. Candau (United States Patent No. 868,253 of Oct. 15, 1907; ELECTROCHEM. & MET. IND., vol. V., p. 471). Briefly, it is as follows: Barium sulphide is produced from barium sulphate by electrolysis, as is also zinc sulphate from metallic zinc. By mixing the two solutions lithopone is produced. The advantages claimed for this process are that a very white pigment is made and that metallic zinc waste can be used without purifying the resulting salt.

GALVANIZING.

During the year the process of "Sherardizing" or "Dry Galvanizing" has been introduced into this country. Articles to be coated, after cleaning in the usual way, are placed in blue powder or zinc dust in an air-tight iron cylinder, which is then heated to 300 deg. C. or more. The articles when taken out are covered with a layer of zinc, which seems to have alloyed with the other metal. The United States Dry Galvanizing Co., which has been formed to exploit this process, has a small demonstrating plant in operation. A larger plant is in course of erection in New Jersey.

A device for electric-plating small as well as large articles is the invention of L. Potthoff, president of the United States Electro-Galvanizing Co. (United States Patent 866,959 of Sept. 24th, 1907; ELECTROCHEM. & MET. IND., vol. V., p. 331). This apparatus has been in practical use and is said to give good results.

Contributions to the literature of zinc have not been wanting and attention is called to the following articles and papers:

Ueber den Flotation Process, C. Goepner, "Metallurgie," 1907, p. 522-543.

Acid Flotation Process, F. H. Jackson, "Min. & Scient. Press," 1907, 6-8.

Gattierung von Zinkblende und Galmei, J. Juretzka, "Metallurgie," 1907, p. 84.

"Studien ueber das Verhalten von Eisen Oxyden zu Zinkblende," C. H. Graumann, "Metallurgie," 1907, p. 69.

"Versuche ueber die Reduktion von Zinkoxyd," F. O. Doeltz and C. H. Graumann, "Metallurgie," 1907, p. 290.

"Physical Factors in the Metallurgical Reduction of Zinc Oxide," W. MacJohnson, in the "Bi-monthly Bulletin of the Am. Inst. of Mining Eng., No. 17, 1907, and ELECTROCHEM. & MET. INDUSTRY, vol. V., p. 498.

"The Electrometallurgy of Zinc and its Relation to Recent Practice," two papers, by W. MacJohnson, the first in ELECTROCHEM. & MET. IND., vol. V., p. 83, the second in *Trans. Am. Electrochem. Soc.*, 1907.

"Electro Deposition of Zinc," R. S. Snowdon. Trans. Am. Electrochem. Soc., 1907.

"The Electro-Metallurgy of Zinc," Gustav Gin, paper read before the Electrochem. Society.

"Theory and Practice of Sherardizing," Alfred Lang, "Electrochem. & Met. Ind.," 1907, p. 187; "Iron Age," 1907, vol. 79, pp. 1554, 1646.

"Report of the Sub-Committee on Zinc Ore Analysis," by Geo. C. Stone and W. C. Waring.

"Die Untersuchungs-Methode des Zinks unter besonderer Beruecksichtigung der technisch-wichtigen Zinkerze," H. Nissenson.

From the foregoing it will be seen that the old retort process is still being improved. The treatment of complexed sulphides seems, however, to have received the greatest attention. The thermo-electric processes may finally offer a satisfactory solution, especially where cheap water power is to be had and coal difficult to get. However, many difficulties must still be overcome and, besides, improvements in the present practice are still possible, opening a wide field to the inventive mind.

Purification of Gases.

BY OSKAR NAGEL, PH. D.

Separation of Gases from Solids.

The removal of dust from gases is quite an important metallurgical and chemical problem, which can be solved in different ways. In all the processes used for this purpose, however, it is necessary to cool the gas before separation can be effected. In some cases a simple cooling by means of

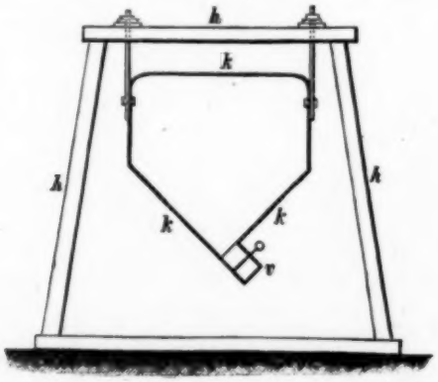


FIG. 1.—COOLING APPARATUS.

certain appliances is sufficient to remove the dust nearly completely. Such a gas or air-cooling apparatus is shown in Fig. 1. It consists of a sheet-iron channel *k*. The dust collects upon the bottom of same and is removed through openings *v* provided in certain distances. The friction of the gas current with the walls of the channel facilitates the separation.

Filtration is frequently employed for collecting dust which is contained in gases in a finely-divided state. In the manufacture of zinc oxide, for instance, the air containing the oxide is filtered through bags in which the solid particles are retained.

A decrease of the velocity of the gas current also facilitates the separation. For this purpose the gases are led into chambers or channels before they are allowed to escape through the stack. As decrease of draft is not nearly as effective as frequent and continued contact with large surfaces, narrow channels are more advantageous than large chambers.

Another way of causing separation is the change of the direction of the gas current, which is the more effective the cooler the gas. Zig-zag shaped channels are used for this purpose.

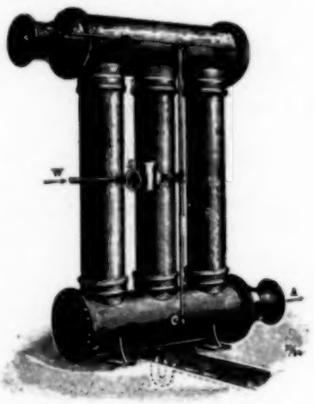


FIG. 2.—DUST COLLECTOR.

For removing the dust from blast-furnace gas, wet processes are almost exclusively used. In the Zschocke system (illustrated, ELECTROCHEMICAL AND METALLURGICAL INDUSTRY, Vol. IV., p. 396, Fig. 1) the gas is washed in scrubbers, which are so constructed that they cannot be clogged up by the dust. In the Theisen system (illustrated in ELECTROCHEMICAL AND METALLURGICAL INDUSTRY, Vol IV., pp. 396 and 397, Figs. 2 to 5) the gas is exposed to the action of a rapidly revolving fan into which water is injected, the removal of the dust being due to centrifugal force. An apparatus of the same class is built by the Buffalo Forge Co. A "moist" dust collector, which works very satisfactorily, is built by the Schuette & Koerting Co. in Philadelphia (Fig. 2). In this system the gas or air to be purified enters at E. The removal of the dust is effected by spray nozzles. The air leaves at A, the water containing the dust at L.

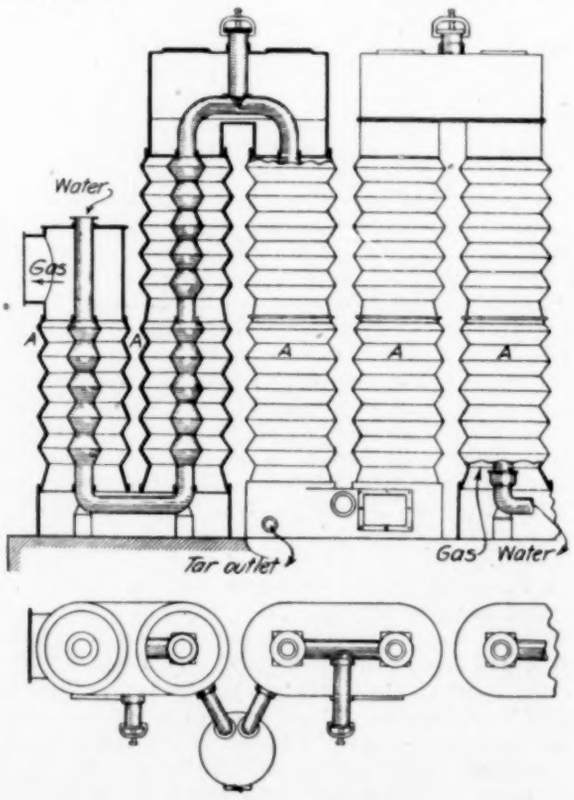


FIG. 3.—COOLER.

Separation of Gases from Liquids.

If it is desired to separate gases from liquids in which they are absorbed, the process to be applied will be different according to whether the gas liberated is to be used or wasted. In

the former case a distilling apparatus with condensing cooler will have to be used, while in the latter case an evaporating apparatus can be applied. Gases that are absorbed by liquids at high temperatures can be conveniently separated by cooling the liquid. An apparatus which is successfully used for this operation is Mohr's cooler, Fig. 3. It consists of zig-zag shaped pipes containing in the interior cooling pipes of the same shape. The pipes A are connected at the top and at the bottom by so-called connecting boxes; in the bottom boxes outlet openings are provided for the liquids separated.

The separation of gases and liquids is of considerable importance in the manufacture of illuminating gas; as the apparatus used heretofore can also be used in other analogous operations occurring in the chemical and metallurgical industries, we are going to discuss the principal types.

FIG. 4.—TAR EXTRACTOR.

The most widely used tar-extractors are the ones of the Pelouze and Audouin type; they are built in the United States by the Gas Machinery Co., Cleveland, Ohio. Fig. 4 shows the general view of a tar extractor, Fig. 5 the drum and Fig. 6 a cross-section.

This apparatus consists mainly of an outer cylindrical cast-iron cover, provided with inlet and outlet openings for gas and overflow, for products of condensation, and contains a drum of perforated sheet steel counterbalanced by a weight on the outside, the connection being made through a hydraulic seal on top of the apparatus. The drum constitutes the extractor proper. The inner sheet is perforated with rows of closely spaced round holes, and the next sheet with large rectangular slots, so arranged as to offer a blank surface opposite the small holes of the inner sheet. The two outer sheets are similarly arranged and are provided to increase the efficiency of the apparatus.

On entering the inlet the gas ascends into the cylindrical chamber, passes through the perforations of the drum, and is divided into small jets, which strike against the solid surface sheets placed close to the perforated plates. In passing through the small perforations the liquid molecules are wire-drawn, and therefore brought into close contact with one another, the action being completed by contact with the solid surface upon which the tarry matter is deposited, whence it flows down the surface of the plate into the annular tar chamber, and from there through the overflow to the tar well.

The drum properly balanced is capable of acting as its own regulator; when there is an increased make of gas the cylinder rises, and a great number of perforations are exposed to the passage of the gas.

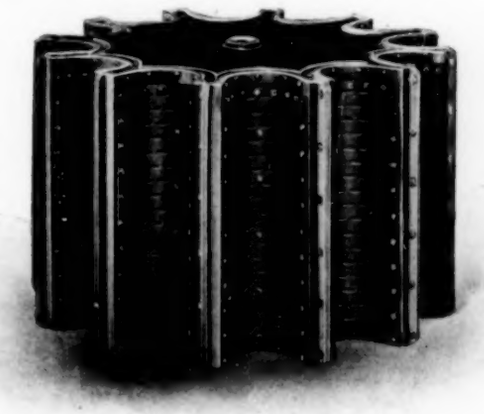


FIG. 5.—DRUM

Separation of Gases from Gases.

For separating gases from gases, in most cases the absorption process is used in practice. The gas not absorbed by the liquor used can be collected and the absorbed gas worked up separately.

If the gas mixture consists of more than two gases, as is the case, for instance, with crude coal gas, the various gases are absorbed consecutively in various vessels.

As the liquefaction of different gases depends on pressure and temperature, this property can also be used for separating gases (Gailey's process of drying the blast).

The following examples will show the most important types of apparatus used for separating gases:

An apparatus for removing and absorbing ammonia from gases, as built by the Gas Machinery Co., Cleveland, Ohio, is shown in Figs. 7 to 9. Fig. 7 shows a section through the washer parallel with ducts, Fig. 8 a cross-section of ducts in operation, and Fig. 9 a section through the washer across the ducts.

This washer consists of a rectangular cast-iron box and a top cover of sheet steel. A gas-inlet distributing box and a gas-outlet box are bolted to the outside of two side plates and provided with openings for gas inlet and outlet connections. Ducts of sheet steel, specially perforated, extend horizontally across the inside of the washer, one end of the upper circular part of the ducts connecting through round openings in the inlet side plate with the inlet distributing box, and the other end placed against round openings in the opposite side plate. The upper or outlet compartment above the ducts is connected with the gas-outlet box by means of a long horizontal opening placed near the top of the box.

The washer is allowed to fill with liquor until the depth of seal through which the gas has to force its way will show a differential pressure of about 3 inches. The overflow should be set to allow the liquor just to pass when this point is reached, the cock in the equalizing pipe being open.

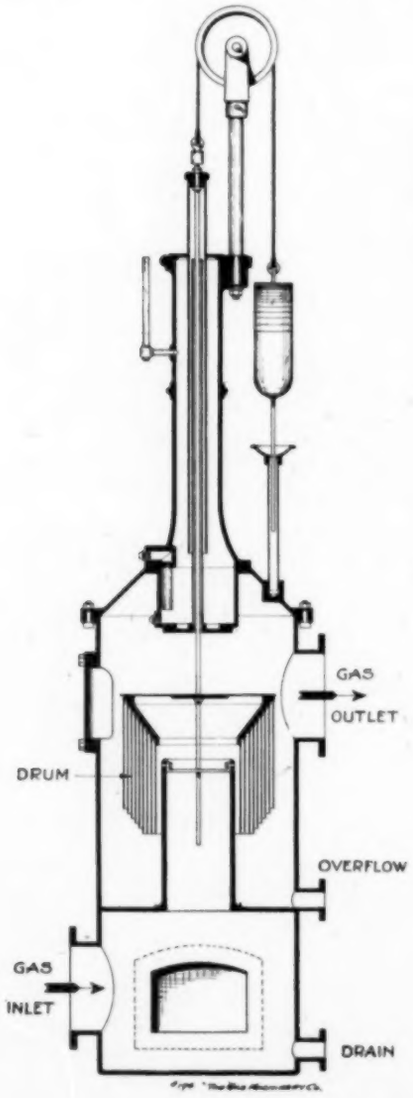


FIG. 6.—CROSS-SECTION OF TAR EXTRACTOR.

The gas first passes into the inlet distributing box and through the circular openings in the inlet side plate into the upper parts of the ducts, depressing the liquor in the narrow throat of the ducts and passing through the small holes in the slanting surface of the submerged part, thereby effecting a fine distribution of the gas, which passes up through the liquor in minute bubbles.

The gas then goes into the top of the washer and through the long horizontal opening into the outlet box.

The long horizontal outlet opening extends nearly the whole width of the box, and is made of ample area to allow for the slow and easy passage of the gas. This prevents carrying entrained water with the gas.

Of entirely different construction is the gas absorption apparatus of Schuette & Koerting, in Philadelphia. Here an extremely fine spray of water, which is produced by means of the Koerting spray nozzle, is applied to the gas mixture. Fig. 10 shows an installation of this type for the absorption of hydrofluoric acid gas. A hood is placed over the pit and is connected to a wooden tower, to the top of which spray nozzles are attached. The vapors free of hydrofluoric acid gas pass through the outlet to a chimney or fan.

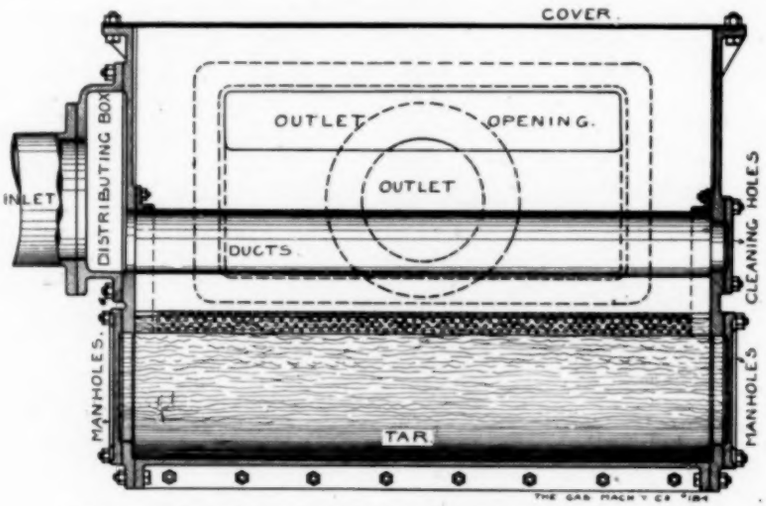


FIG. 7.—SECTION OF APPARATUS FOR ABSORBING AMMONIA FROM GASES.

On the Direct Reduction of Alumina by Carbon.[1]

By R. S. Hutton and J. E. Petavel.

The methods used in practice for obtaining aluminium from its ores are indirect and inefficient.

The preparation involves a lengthy and complicated purification of the oxide, followed by its electrolysis in a bath of cryolite. Early work showed that where aluminium alloys are required they could be obtained by a simple method involving the reduction of aluminia by carbon, but the process has never been successful for the production of the pure metal. Up to the present time opinion seems to be divided as to the effect of heating alumina and carbon together in the electric furnace.

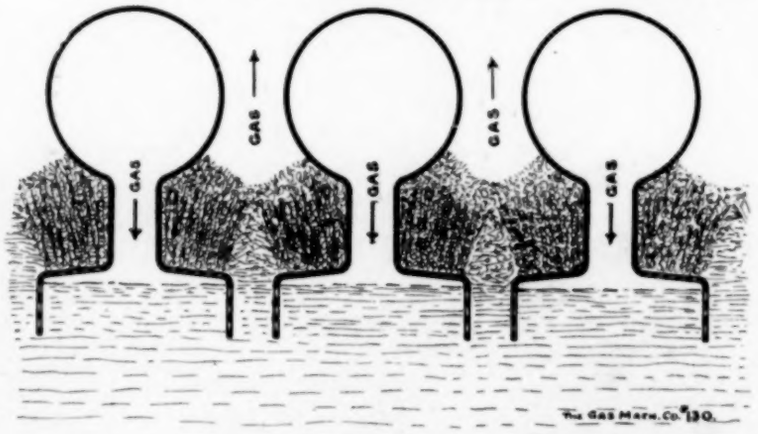


FIG. 8.—CROSS-SECTION OF DUCTS IN OPERATION.

Several authorities definitely state that alumina is irreducible by carbon,[2] whilst others affirm that it is quite easily reduced.[3]

[1] This is part of a paper read before the Royal Society of London, on electric furnace reactions under high gaseous pressure. While a brief summary of the chief results of this very extended investigation was already given on page 242 of our Vol. V., a fuller account will be found elsewhere in this issue.—Editor.

[2] W. Hampe, Chemiker-Zeitung, 1888, 12,291; S. A. Tucker and H. R. Moody, Jour. Soc. Chem. Ind., 1901, 20,970.

[3] Cowles, see W. P. Thompson, Jour. Soc. Chem. Ind., 1886, Vol. V., p. 206; W. Borchers, Elektro-Metallurgie, third edition, 1908, p. 102.

Moissan,[4] taking an intermediate position, asserts that the two materials only react when in the form of vapor.

The question, which for many reasons is of considerable importance, has never received the detailed investigation which it deserves.

Our experiments at atmospheric pressure, as we shall see, pointed to the fact that a well-marked thermal reaction does take place, but not until the fusing point of alumina is reached.

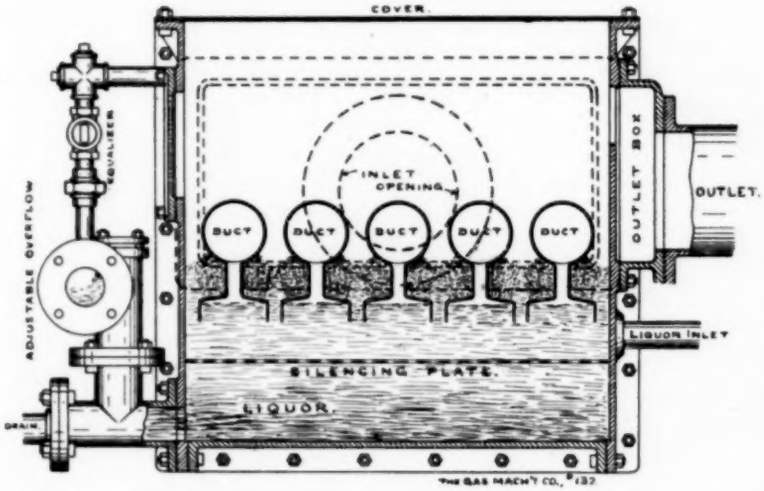


FIG. 9.—SECTION THROUGH WASHER ACROSS THE DUCTS.

Héroult,[5] while admitting that reduction occurs, attributes it to electrolytic action. Having carried out some experiments in which the reacting substances were heated by radiation alone, and in which good yields of aluminium bronze were obtained, we contend that the assumption of electrolysis is by no means necessary.

No information was available as to the temperature of vaporization of metallic aluminum, but various observations led us to believe that a large proportion of the reduced metal was lost by volatilization and subsequent combustion where the furnace gases come in contact with the air.

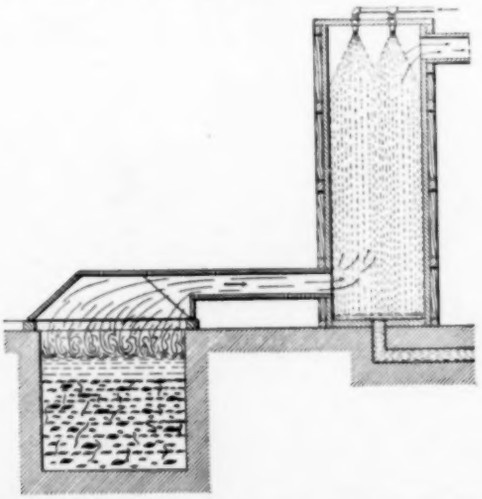


FIG. 10.—APPARATUS FOR ABSORBING HYDROFLUORIC ACID GAS.

The high-pressure furnace[6] seemed to us, therefore, particularly suitable for studying this question, the advantages to be gained consisting in the complete protection of the products from oxidation, and secondly in the decreased volatilization which might be expected under the high gaseous pressures.

Some of the experiments tried under pressure to study this problem are given in Table I.

By a cursory inspection of Table I. the two following facts may be at once deduced:

(1 That in the resistance furnace neither aluminium nor its carbide is produced.

(2 That, on the other hand, all arc furnaces give a more or less marked reduction; although it will be noticed (in section B) that the product chiefly occurs as carbide of aluminium.

In several cases small malleable lumps of the metal were condensed in the powdered material surrounding the fused product.

From this it would appear that the required conditions for which we are searching had for some short period been accidentally fulfilled—these conditions being the rapid removal of the metal vapor from the reduction zone and its condensation under circumstances which preclude carburization.

The idea that, by reducing the partial pressure of the carbon monoxide by a circulation of hydrogen or coal gas, more favorable results would be attained led to the experiments quoted in Table I, C and D. From these we infer that the reaction is considerably favored by a dilution of the carbon monoxide. It is further noticeable that this precaution results in an increase in the relative quantity of aluminium metal, although it is still accompanied by a considerable amount of the carbide.

It therefore became evident that further work at high pressures must be preceded by a more detailed study of the conditions of reduction. The several problems which arise may briefly be stated as follows:

(1) At what temperature does alumina first show signs of reduction by carbon?

(2) In the production of aluminium alloys, what is the function of the auxiliary metal in facilitating the reduction of alumina?

(3) What precautions are necessary to limit the formation of carbide and increase the production of metal?

Since it is well known that alumina cannot be reduced under ordinary circumstances in the Moissan furnace, it was thought advisable to see whether, by carrying out the reaction in an atmosphere of hydrogen, a definite indication or reduction could be obtained. The Moissan furnace was, of course, modified to exclude the use of limestone and the accompanying production of carbon monoxide.

As will be seen from Table II. A, a negative result was obtained.

As a means of limiting the temperature of reaction, calcium fluoride was introduced, but no signs of reduction were apparent at the boiling point of the bath. From these and similar negative results at lower temperatures, which it is unnecessary to record, we assumed as a working hypothesis that the temperature of reduction of alumina is above the boiling point of aluminium metal under atmospheric pressure.

The hypothesis we confirmed by experiments (Table II. B), in which special precautions were taken to protect the material from access of air and to provide a condensing chamber in which the vapors were cooled down before their exit from the furnace. The deposit so obtained showed unmistakable evidence of the presence of finely divided aluminium.[7]

It therefore became necessary to devise some better means for indicating the production of any metal vapor.

A method which suggested itself to us, and one which has

[4] H. Moissan, The Electric Furnace, London Ed., Arnold, p. 184.
[5] P. L. T. Héroult, Eng. Pat. 16,853, 1887; also Congress intern. des Mines et de la Metallurgie (Paris), 1900.
[6] See the abstract of the complete paper of the author's in this issue.
[7] See also C. F. Mabery, Amer. Chem. Journ., 1887, Vol. IX., pp. 11-15.

proved of considerable usefulness, was the employment of a bath of molten copper, on the surface of which the reaction mixture was placed. The copper served as an absorbent for any aluminium vapor liberated.

To determine the lowest temperature at which reduction occurs, a series of experiments was carried out. Small carbon crucibles were used to contain the mixture. These were heated either in a carbon-tube furnace, or, for higher temperatures, more conveniently by embedding them in a granular carbon resistor. From the summary of these experiments in Table II. C, it will be seen that the minimum temperature of reduction coincides fairly sharply with the melting point of alumina, and is not appreciably lowered by the introduction of either fluorspar or lime as a flux.

By referring again to Table I. it will be found that this view is substantiated by a comparison between the arc and resistance experiments.

In the latter the yield is always extremely low. This may be explained by the fact that as the inner layer of mixture approaches its fusing point it flows away by gravity, and, ceasing to transmit the current, is not maintained at the requisite temperature for marked reduction to occur.

We now come to that curious apparent contradiction of facts which has for so long puzzled investigators in this field, namely, that though aluminium bronze and ferro-aluminium can be so readily produced, no process exists by which the metal itself can be obtained from the oxide, except by indirect means. What is, then, the function of the auxiliary metal? It has been suggested that a marked chemical affinity exists between the aluminium and the metal with which it alloys, the evidence in support of this being the high heat evolution which is noticeable when aluminium is added to the metals in a molten state.

It must, however, be remembered that under ordinary conditions the fused metals contain dissolved oxide, and it therefore seemed worth while to carry out a preliminary investigation of this question.

Upon adding aluminium to molten copper in a thoroughly reduced condition, there is no visible evidence of a reaction, and such pyrometric measurements as were made sufficed to show that no considerable amount of heat could have been evolved.

Thus we feel justified in concluding that the copper or other metal serves chiefly to condense and dissolve the aluminium, and does not itself take part in the primary chemical reduction of the oxide.

A secondary function of the auxiliary metal is, however, possible. It occurred to us that the absence of aluminium carbide, when reduction is effected in the presence of other metals, might be explained by some chemical action of the

TABLE I.

Experiment No.	*Total Energy, Kilowatt Hours.*	*Average Power, Kilowatts.*	*Initial Pressure, Atmospheres.*	*Maximum Pressure, Atmospheres.*	*Product, Grams Al Metal.*	*Product, Grams Al_4C_3.*	*Observations.*
A.—Resistance Furnace CO Retained.							
G 19	16.0	9.6	63 air	157	Insignificant	Insignificant	Granular carbon core graphitized and containing much alumina fused around its particles.
G 41	2.5	9.0	6 nitrogen	25	Insignificant	Insignificant	Core of soot and alumina surrounded by pure alumina; to ascertain effect of fine division and intimate mixing. Tube of fused alumina around core, but no evidence of reduction.
G 44	3.2	6.5	Atmospheric	17	Insignificant	Insignificant	Experiment similar and confirmatory to G 41.
B.—Arc Furnace, CO Retained.							
G 17	9.4	7.8	Atmospheric	44	5.0	47.7	Central cavity formed, having at bottom disc of fused reduction product resting on graphitized pillar of carbon.
G 32	4.6	8.2	Atmospheric	35	13.0	102	Similar to G 17.
C.—Resistance Furnace, CO Diluted and Removed.							
G 18	16.0	16.0	26 hydrogen	110	3.3	20.9	No diluting gas added during run. Resistance core granular carbon, after run no core remaining.
G 77	11.4	11.7	55 hydrogen	100	3.2	60.1	Current of hydrogen through hollow electrode. During run, 900 litres; during cooling, 420 litres. Furnace with core of alumina and carbon between the two carbons.
D.—Arc Furnace, CO Diluted and Removed.							
G 20	7.2	17.2	39 coal gas	133	46	262	No diluting gas added during run. Some lime added to mixture. Fused product contained large amount of graphite flakes.
G 21	8.0	16.0	15 coal gas	25	49	106	The furnace was alternatively filled with coal gas to 25 atmospheres and gas blown down to 15 amperes; 600 litres coal gas during run, 1200 litres cooling period. Some lime added to mixture. Little graphite formation.
G 24	14.6	13.4	60 coal gas	90	31.8	198	Current of coal gas continuously passed through furnace at a rate of about 0.5 litre per second, pressure being maintained approximately constant at its maximum value.
G 33	9.1	9.8	15 coal gas	30	46	228	*Regime* of gas circulation similar to G 21. During run, 800 litres; during cooling about 800 litres also.
G 36	2.0	8.0	3 hydrogen	5	6.5	45	Reduction of alumina by calcium carbide. No diluting gas added during run.
G 75	15.3	9.8	50 hydrogen	70	17.7	130	Current of hydrogen through hollow carbon electrodes. During run, 900 litres; during cooling, 600 litres.
G 76	6.3	7.9	40 hydrogen	80	23.5	76.2	*Regime* of gas circulation similar to G 75. 510 litres during run; 450 litres during cooling

N. B.—In all these experiments the mixture contained less than the theoretical amount of carbon.

aluminium carbide upon the copper or iron or one of their oxides.

An investigation of this matter has been undertaken by J. N. Pring,[8] whose results clearly show that at the temperatures we are considering, namely, at or above the melting point of alumina, aluminium carbide reacts with either the oxide or the metal, forming an alloy.

The third problem, viz., the limitation of the formation of carbide, seems to be the most difficult to solve.

As we have seen, the metal may be considered to exist in the form of vapor at the moment of its reduction. Owing to the well-known affinity of aluminium for carbon monoxide,[9] it is obviously important to remove this gas as completely and rapidly as possible.

A method of reducing the partial pressure of the carbon monoxide has been dealt with above, and we have found it important to lead the gas used for dilution directly to the seat of reaction by means of a hollow electrode, the stream of gas thus not only effectively diluting the carbon monoxide, but serving to carry forward the metallic vapor into a zone more favorable for its condensation.

Even in the absence of carbon monoxide, carburization can

TABLE II.—EXPERIMENTS ON THE REDUCTION OF ALUMINA BY CARBON AT ATMOSPHERIC PRESSURE.

A.—RADIATION HEATING FROM ARC.

Experiment Number.	*E. M. F. on Furnace, Volts.*	*Current, Amperes.*	*Duration, Minutes.*	*Product.*	*Observations.*
G 45	40	140	5	Fused Al_2O_3. No Al metal or carbide...	Mixture corresponding to $Al_2O_3 + 2C$ placed under arc on alumina bed. Furnace enclosed. Hydrogen circulation.
G 46	25	240	14	Fused lump of Al_2O_3. No Al metal or carbide.....	Similar experiment to G 45.
G 47	40	300	10	No aluminium or carbide	CaF_2 used as flux (28 per cent.) with same mixture as above. Heated until very rapid vaporization of fluorspar. Furnace ordinary Moissan type. Material in carbon crucible.
G 48	42	300	10	No aluminium or carbide.....	Larger percentage of fluoride (61 per cent.), otherwise similar experiment to G 47.

B.—RESISTANCE CORE OF MIXTURE.

Experiment Number.		*Product.*	*Observations.*
G 61	Total energy, about 1 kilowatt hour; power, 4 kilowatts.....	Fused lump of alumina. No Al or carbide.....	Cross-section of furnace hearth, 130 sq. centims.; length, 20 centims. Charge, consisting of central core of alumina and carbon surrounded by pure alumina. Thick iron plates served to cover furnace. No aluminium condensate obtained.
G 62	Total energy, 5.8 kilowatt hours; power, 7 kilowatts.....	Condensate, but negligible Al in fused lump.....	Similar construction to above, but cover fitting air-tight, and provided with long condensing chamber. Escaping gas deposited sublimate containing finely divided aluminium.

C.—APPROXIMATE ESTIMATION OF TEMPERATURE OF REDUCTION.

Experiment No.	*Mixture.*	*Temperature Estimated.*	*Result.*	*Observations.*
G 55	A.—10 grams (Al_2O_3+2C) + 40 grams Cu.....	M. P. Ni.....	No appreciable reduction.	Experiment in carbon tube furnace with careful adjustment of temperature.
	B.—10 grams $(Al_2O_3 + 2C)$ + 40 grams Cu.....	M. P. Pt.....	No appreciable reduction..	Experiment in carbon tube furnace with careful adjustment of temperature.
	C.—10 grams $(Al_2O_3 + 2C)$ + 40 grams Cu.....	Above M. P. Pt, but below M.P. Al_2O_3...	No appreciable reduction..	Experiment in carbon tube furnace with careful adjustment of temperature.
G 57	A.—8 grams $(Al_2O_3 + 2C)$ + 25 grams Cu + 10 grams CaF_2	Above M.P. Pt, but below M.P. Al_2O_3..	No appreciable reduction..	Experiment in carbon tube furnace with careful adjustment of temperature (mixture well fused).
	B.—72 grams $(Al_2O_3 + 2C)$ + 25 grams Cu + 8.5 grams CaO	Above M.P Pt, but below M.P. Al_2O_3....	No appreciable reduction..	Experiment in carbon tube furnace with careful adjustment of temperature (mixture well fused).
G 58	A.—10 grams $(Al_2O_3 + 2C)$ + 50 grams Cu.....	Just above M.P of alumina.....	46 grams aluminium-bronze (6.6 per cent.Al)	Crucible containing mixture embedded in granular carbon, covered with a second crucible containing alumina. Latter showed no sign of fusion.
	B.—10 grams $(Al_2O_3 + 2C)$ + 50 grams Cu.....	Considerably higher temperature.....	49 grams aluminium-bronze (7.8 per cent. Al).....	Similar construction alumina in upper crucible also fused. All the mixture either combined or volatilized.

[8] J. N. Pring, Trans. Chem. Soc., 1906, Vol. LXXXVII., p. 1530.

[9] Guntz and Masson, Comptes Rendus, 1897, Vol. CXXIV., p. 187.

occur by direct union of the metal with solid carbon.

Some unpublished work of W. H. Patterson carried out in this laboratory has, however, shown that in the absence of carbon monoxide this reaction only occurs above a bright red heat, thus explaining the results already quoted in which the metal was obtained, although doubtless it had not altogether escaped contact with carbon.

We are, therefore, in the following position: we have proved the facility with which the direct reduction of alumina by carbon can be effected, and have shown the minimum temperature at which it can occur is already sufficiently high for the metal to be produced in the form of vapor.

Future work must be directed towards the application of high pressure for reducing the vaporization of the metal at the temperature of reaction, the rapid removal or dilution of the carbon monoxide by a steam of inert or reducing gas, and a modification of the *régime* to facilitate the condensation and prevent the collected metal from flowing into a bed of highly heated carbon.

Thus the necessary conditions for the successful direct reduction of alumina by carbon seems to be fairly well defined, the outstanding problem being chiefly a matter of the arrangement and construction of the furnace.

The Von Bauer Coke-Oven System.

The by-product coke-oven system described in this article has been devised by Dr. Theodor von Bauer, who is one of the most experienced coke-oven engineers in Germany. In its present state his system is the outcome of changes and improvements which have been made gradually in the course of years. The von Bauer coke-oven patents are controlled in Europe by the Berlin-Anhaltische Maschinenbau Aktien Gesellschaft (commonly known in Germany by the abbreviation "Bamag"). This company is noted as very large builders of gas works and manufacturers of apparatus for all kinds of gas plants; they have also shipped much of their machinery to this country. To take care of the construction of the von Bauer coke-ovens, the Gesellschaft für Erbauung von Hüttenwerksanlagen, Dusseldorf, Germany, a subsidiary company of the Bamag, has been founded. Its chief engineer is Mr. O. Simmersbach, well known as a high authority on this subject and as the author of a book on the chemistry of coke.

This coke-oven system is now being introduced into this country by Mr. David B. Carse, formerly of the United States Steel Corporation, and by Mr. Frederick J. Mayer, a distinguished gas engineer. As this system is radically different from others now in use, a detailed description should be interesting at this moment. The following description is based in its first part on an article by Mr. O. Simmersbach in *Stahl und Eisen* (No. 24, 1906). Some recent improvements effected by Dr. von Bauer since the publication of that article will then also be noted.

In the latest design of the von Bauer coke ovens longitudinal flues are provided on top of the combustion chambers between the coking chambers. These two flues are arranged immediately above each other. All the upper flues communicate with the lower flues of the same set by means of a series of openings, and in a similar manner, also, with the upper flues of the adjoining sets across the tops of the intervening coking chambers. The lateral flue connections also pass over the charging openings on top of the coking chambers.

This flue arrangement assures not only a uniform distribution of the fuel gases into the vertical combustion chambers, but also in the case of "direct" operation a uniform composition of the same by mixing the crude gases from the coking chambers, which, naturally, vary in their composition, according to the more or less advanced state of the coking process in the various chambers of the battery, in the upper flues before entering the lower distributing flues and from there the combustion and heating chambers.

In the case of "indirect" operation, the auxiliary fuel gas supply enters the upper and lower flues from the outside, and is distributed in the upper and lower flues from the outside and is distributed in the lower flues into the combustion or heating chambers. The change from the "direct" operation of the coke to the "indirect" is accomplished by disconnecting the upper flue system from the charging openings on top of the coking chambers and using the upper and lower flues for the reception, mixing and distribution of the fuel gases coming from the condenser or of auxiliary fuel gases from other sources into the combustion chambers.

The design of the latest improved coke oven, as it was at the writing of Mr. Simmersbach's article in 1906, is shown in the accompanying illustrations, Figs. 1 to 5.

Fig. 1 represents a vertical section through the upper part of a number of coking chambers, showing the method of operating a "direct-fire" coke oven for "hand" charging (A), a "direct-fire" coke oven for "machine" charging (B), as well as the method of operating a "by-product" coke oven for hand charging (C) and for machine charging (D).

Fig. 2 represents a vertical section through the combustion chambers; Fig. 3 a similar section through a coking chamber of a coke oven.

Fig. 4 represents a horizontal section, showing at a reduced scale the arrangement of the upper and lower flue systems.

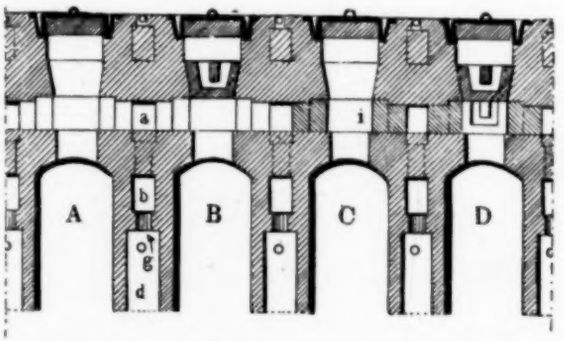


FIG. 1.—THE DIFFERENT METHODS OF OPERATING THE VON BAUER COKE OVEN.

A = "Direct Fire" with hand charging.
B = The same with machine charging.
C = "Indirect Fire" or By-Product oven with hand charging.
D = The same with machine charging.

Fig. 5 represents a vertical cross-section, showing the end of a battery of coke ovens with flue for the removal of the surplus gases.

Above the walls between the coking chambers are located the mixing flues *a*, which are in connection with the charging chutes, or shafts of the coking chambers, and also with the adjoining mixing flues. Below the mixing flues *a* and in the walls between the coking chambers are located the distributing flues *b*, which communicate with the mixing flue above and with the combustion chambers or heating flues below; the latter being also arranged in the walls between the coking chambers.

By the "direct" operation of the coke oven and "hand" charging, it is only necessary to insert the covers for the charging openings in top of oven (Fig. 1 A), while for "machine" charging the additional lower removal covers are inserted and made gas tight with a filling (Fig. 1 B). In both cases, however, the mixing flue system *a* remains in connection with the charging openings in the top of the coking chambers as well as with the distributing flue systems *b*.

The crude gases generated in the coking chambers, and which vary as to their composition, enter the mixing flue system *a*, where they are mixed so as to attain a more uni-

form composition. From this mixing flue system *a* the gases pass into the distributing flue system *b*, and from there finally through the openings *g* into the combustion chambers or heating flues *d* in the walls between the coking chambers. In order to operate the coke ovens on the "indirect" system it is only necessary to close the connections between the mixing flue system *a* and the charging chutes, or shafts, by means of firebricks *i*. By "hand" charging (Fig. 1 C) only one cover is used for the closing of the shaft, but by machine charging (Fig. 1 D) an additional cover with sand filling is used.

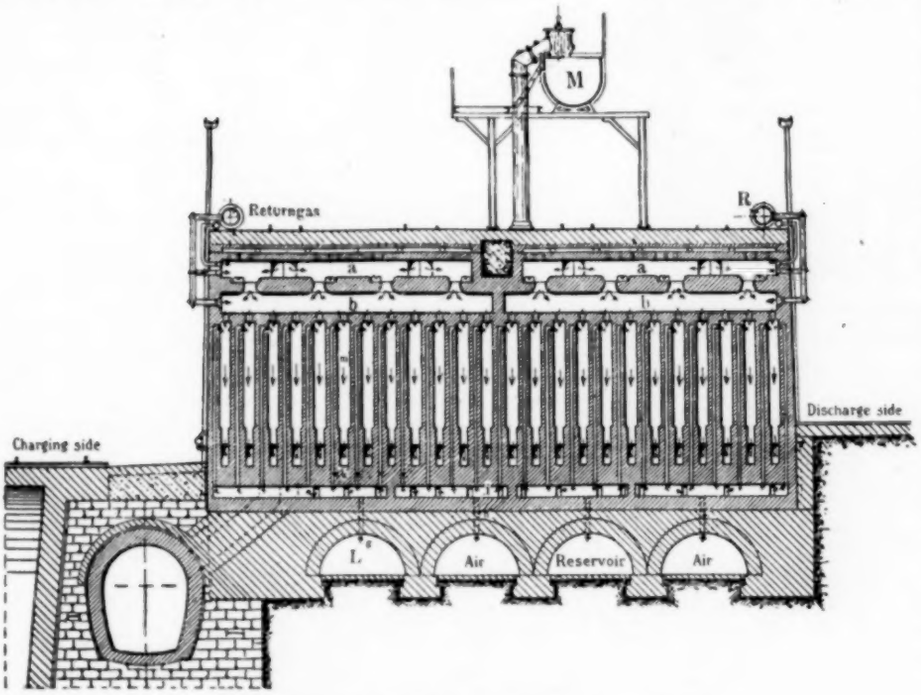


FIG. 2.—SECTION THROUGH THE COMBUSTION CHAMBERS.

In the coke ovens thus arranged for "indirect-fire" operation, the flue systems *a* and *b* receive the purified gases from the oven, or an auxiliary fuel gas supply, from another source for distribution into the combustion chambers in the same manner as the crude gases when operating the ovens "direct." The auxiliary gas supply may be used exclusively or for mixing with the purified gases from the coke ovens.

A small steam pipe discharging into the mixing flue *a* is used for blowing out from time to time any soot that may accumulate when operating the coke ovens "direct." This avoids the necessity of cleaning these flues by hand, which otherwise would result in loss of time, cooling of the flues, etc., if the cleaning were to be effected by hand.

One point of superiority of this coke-oven construction is an increased yield of coke. The yield is even greater than that obtained by the crucible test. Thus, on the Krupp colliery, Hanover, between Jan. 1, 1903, and June 1, 1904, an increase of more than 5 per cent in the yield of coke over that obtained by the crucible test was regularly observed. This is mainly due to the uniform maintenance of the conditions of temperature, which favor a partial decomposition of the heavy hydrocarbons and a subsequent deposition of part of the carbon therefrom upon the coke, and to the arrangement and location of the flues for the preheating of the air supply for the combustion chamber, which precludes any possibility of air entering the coke chambers.

In "by-product" coke ovens these conditions differ in so far as after the charging of a coking chamber (Fig. 3 A), the generated gases rise through the standpipe B into the gas main M leading to the by-product plant for the extraction of tar, ammonia and benzol. The purified gases are returned through the mains R, and by means of special individual connections introduced as fuel gas into the mixing and distributing flue systems *a* and *b*. The provision of a regulating device on these individual connections affords a much closer adjustment of the gas supply than it would be possible with a number of single tuyeres. The reason for this is that a possible more or less of the gas supply at any point will be automatically adjusted by distribution in the mixing and distributing flue system before the fuel gas enters the combustion chambers.

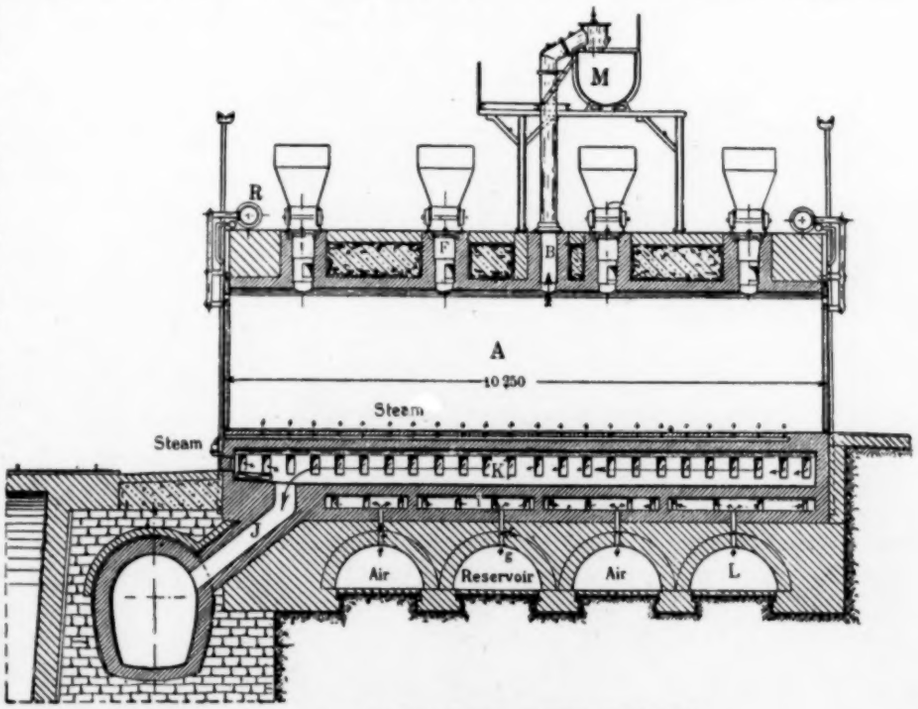


FIG. 3.—SECTION THROUGH THE COKING CHAMBERS.

A uniform gas supply will naturally result in a correspond-

ingly uniform supply of air for the combustion. From the flue systems *a* and *b* the gases enter the combustion chambers (Fig. 2 m), where they meet the highly preheated air. The gases of combustion are then drawn down and collected in the collecting flues K, located under the coking chambers (Figs. 3

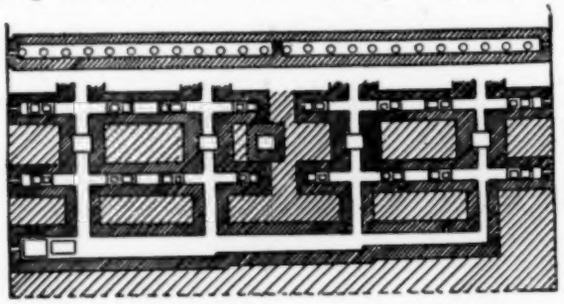


FIG. 4.—HORIZONTAL SECTIONS THROUGH THE UPPER AND LOWER DISCHARGING FLUE SYSTEM.

and 5), and discharged through the connecting flue J into the main flue, to be either further used in boiler furnaces or finally discharged through a chimney.

The air for combustion is taken from the spaces under the ovens formed by the large foundation arches. These arches serve for the preliminary heating of the air supply as well as for the cooling of the oven foundations. This arrangement restricts the required openings in the sides of a battery of ovens to those required for the charging and discharging of the coking chamber of machinery and in the top to those required for admission of coal in the case of hand charging and for the necessary gas take-offs.

In case the ovens are charged with machinery, the charging openings A top are then closed with suitable form blocks, so as to avoid any admission of air into the ovens by that source.

The air for the combustion is supplied in four separate sections, one for each of the four large foundation arches under the battery of coke ovens, the air in-lets to which are provided with adjusting dampers. From these large air reservoirs the air enters through the openings *g* and *h* into the distributing ducts *i*, in which the air, being exposed to the heat from the gas flue K, is heated to about 1,100° F. From the distributing ducts *i* the air rises through special up-takes,

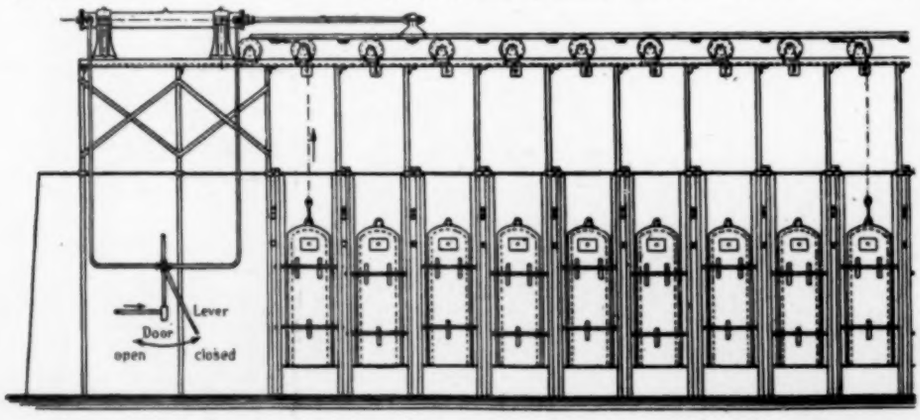


FIG. 6.—ELEVATION OF A BATTERY OF OVENS WITH AUTOMATIC DEVICE FOR OPENING AND CLOSING THE DOORS.

molded in the material forming the walls of the coking and combustion chambers, thereby extracting more and more heat from these walls and increasing its own temperature to about 1,920° F., as has been proven by measurements with electric and optic pyrometers on various coke ovens of this system.

Because of the highly preheated air the combustion is naturally complete, and the resulting high temperature is produced in the combustion chamber at and below the surface line of the coal charge in the coking chamber. Furthermore, as the gases of combustion have a downward course, high temperatures and the resulting superheating of the upper parts of the coking chambers are prevented, and thus also any decomposition of the valuable gases in the coking chamber before their removal through the stand-pipe B into the collecting main M.

The average coking period in the new coke ovens is 24 hours, which corresponds to a yearly capacityy of 180,000 to 190,000 tons of blast-furnace coke for a battery of 100 ovens. The ovens yield from 45 to 50 per cent surplus gas, according to the kind of coal used, while the flue gases, because of their short travel, have a higher temperature than those from such other coke-oven systems, where the flue gases have to pass extensive generators and checkerwork, which necessarily reduce their heating value. Furthermore, the omission of complicated and costly devices for the preheating of the air for combustion reduces the cost of construction of the new ovens considerably and at the same time simplifies their installation and operation.

Numerous tests have demonstrated that in the regular operation of the new von Bauer coke ovens the transmission

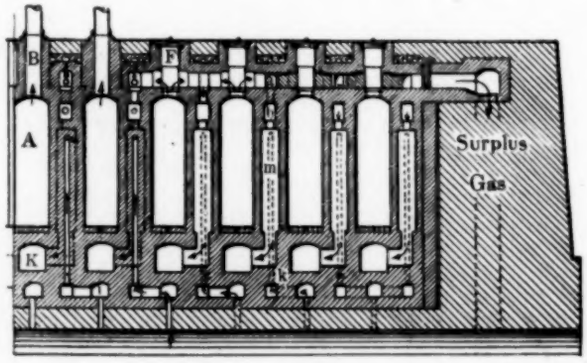


FIG. 5.—CROSS-SECTIONS; END OF BATTERY WITH WASTE HEAT FLUE.

of heat from the walls of the coking chambers to the coal in the coking chamber is gradually reduced towards the end of the coking period, and that the layer of coke nearest the heated wall and the gases generated in the chamber become hotter in the ratio as the coking process advances towards the center of the charge of coal; in fact, so much that during the last third of the coking period the heating of the coking chambers can be dispensed with entirely.

In order to facilitate the completion of the coking process during this period, especially of the inner core of the coal charge, steam is admitted into the coking chamber through a special and patented device, for the purpose of more uniformly transmitting the heat from the walls of the coking chamber through the cracks and pores of the finished outer coke layer to the coking core of the coal charge. Actual experience has proven that with this arrangement the coking period of the new ovens is shorter and the coking process more uniform than without the same. Another advantage of this arrangement is that it increases the yield of the surplus gas considerably, and that, because of the lower temperature of the gases generated during that period, less washing and condensation surfaces are required.

According to Prof. Kassner, of Muenster, the above-described

device applied to by-product coke ovens increases the yield of gas by 30 per cent, and that of tar and ammonia by 50 per cent over the previously possible yields.

The lifting and lowering of the doors of the von Bauer coke ovens are accomplished through a special automatic hoisting apparatus. With this apparatus all doors of one battery can be operated from one place, as it is only necessary to attach a chain to any door and operate the steering valve of the hoisting apparatus, and as this is very light work it can be done by boys. The hoisting or the lowering of a coke-oven door requires not more than from 3 to 5 seconds.

Fig. 6 shows the general arrangement of the apparatus for the hoisting and lowering of the coke oven doors. As a rule, the buckstays of the oven settings are extended a certain distance above the top of the setting, and there connected to each other by a continuous member of shape iron. Upon the latter and over each oven door is placed a small idler for the lifting chain or cable on the same shaft with a larger roller. The latter rollers support a rod, which is provided with suitable eyes or hooks to receive the corresponding hook or eye on the end of the hoisting chain for each door. At one end the rod is coupled in a suitable manner to the piston rod of a working cylinder, which may be operated either by steam, water or compressed air.

The method of operating the device is the following:

As soon as one or more doors are to be opened, the lower hooks on the hoisting chains or cables are attached to the corresponding eyes on the doors, the chains or cables laid over the small idlers above the doors, and the free ends of the chains attached to the corresponding hooks or eyes on the movable rod. Upon opening the supply for the source of power to the front of the cylinder, the piston is moved back, and as the piston rod is coupled to the lifting rod for the doors, the rod is moved to the side and the doors lifted. In order to close the doors, the steering valve of the hoisting apparatus is set so as to release the source of power from the front part of the cylinder, either by letting the same escape or by transferring the same to the other side of the piston.

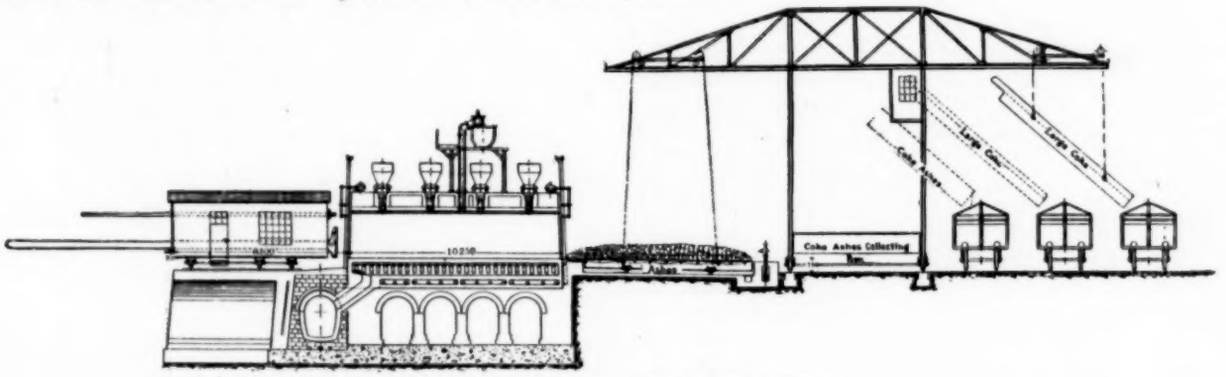


FIG. 7.—TRAVELING COKE-HANDLING DEVICE.

For larger installations of these coke ovens the following electrically-operated device for loading coke direct from the coke ovens into railroad cars has proven to be of great advantage. The device consists of a traveling crane about 33 feet high, with cantilevers 30 feet long and a hoisting trolley with four hoisting cables or chains. Near the base of the four columns of the crane frame is arranged a reservoir for the coke ashes. The coke from the coke ovens is taken up in coke pans, constructed of sheet and shape iron, and arranged on wheels so that they can be placed in front of any of the ovens in the battery. The upper half of these coke pans is arranged as a grate of sufficient length and width to allow for the charge of one coke oven to be conveniently spread out and quenched. The grate is constructed of flat iron on edge, with spaces 3/8 inch to 5/8 inch in the clear. Usually a coke pan of this character is about 30 feet long by 8 feet wide in the clear.

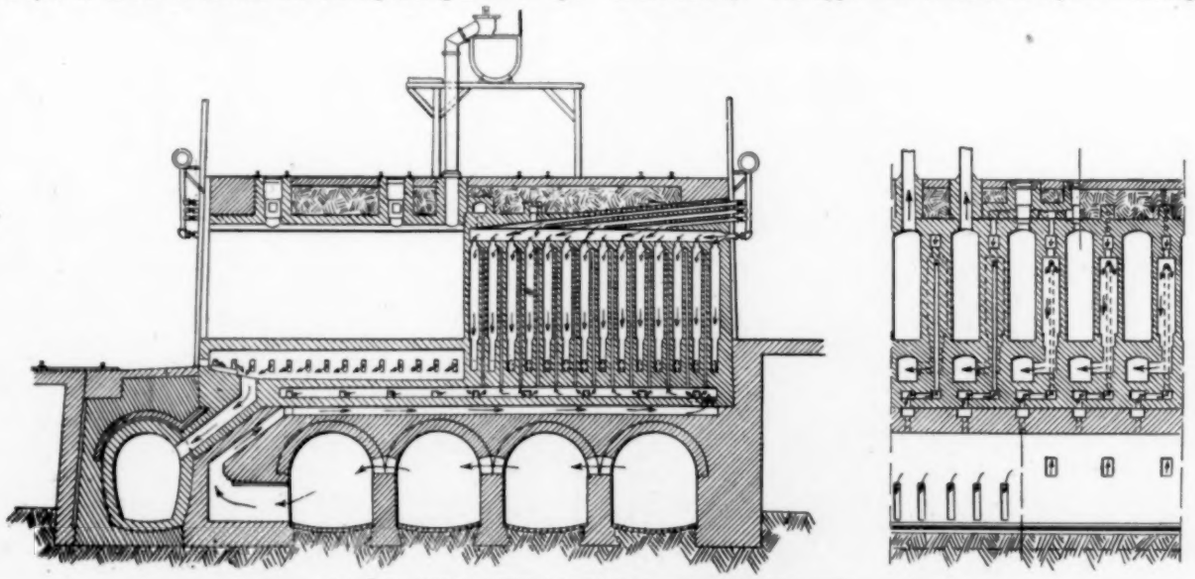


FIG. 8.—LATEST CONSTRUCTION OF VON BAUER COKE OVEN.

The method of operating this device is the following:

As soon as one coking chamber is to be discharged the coke pan is placed in front of the oven, and the discharging machine pushes the finished coke upon the coke pan, and two men immediately spread and quench the coke. In order to allow

the coke to cool, the finished coke from another oven is pushed upon a second coke pan. In case the coke upon the first coke pan is sufficiently cool for loading, the eyes at the ends of the four hoisting cables of the hoisting trolley are attached to the corresponding hooks on the coke pan and hoisted to a height of about 15 feet and run over an empty railroad car. In this position the hoisting mechanism of the hoisting trolley is disconnected from the two front cables, while the two rear cables are further wound up so as to slowly bring the coke pan in an inclined position, which causes the coke to slide off and the the coke ashes to fall through the grating in the bottom of the coke pan, after which the hoisting trolley with the coke pan in the inclined position is run over the ash reservoir, and the accumulated ashes, by opening a damper at the head of the ash box under the grating, deposited in the ash reservoir.

The empty coke pan is then lowered and placed upon the track in front of the ovens ready for the next filling. In the meantime the coke in the second coke pan is sufficiently cooled for loading.

The entire process of loading the charge of a coke oven—that is, attaching the hoisting cables of the hoisting trolley to the coke pan, lifting, running the hoisting trolley to the position for loading the railroad car, unloading the coke and ashes from the coke pan, returning and lowering of the coke pan upon the tracks in front of the coke ovens—requires 10 minutes.

The required labor in connection with the quenching and loading of the coke from forty to fifty coking chambers can be conveniently accomplished by three men in 10 hours, which would correspond to a capacity of the traveling crane of eighty to 100 coking chambers in 24 hours.

Since the publication of Mr. Simmersbach's article, from which the above description is taken, Dr. Th. von Bauer has arranged for other important improvements in connection with the regulation of the fuel gas supply to the distributing flues in the upper part of the oven, by omitting the internal adjusting tiles and substituting the same by independent direct gas supply to different parts of the flue, controlled by valves, all located immediately opposite the upper parts of the partition walls and easily accessible on both sides of the ovens. The matter of preheating the air for combustion has also been improved in this last construction, by lengthening the ducts under the main combustion flue of the ovens. While an installation of the older von Bauer system is at Sydney, Nova Scotia, the new system is to be used in a plant soon to be built in this country.

Metallurgical Calculations.

By J. W. Richards,
Professor of Metallurgy in Lehigh University.

The Metallurgy of Silver and Gold.

The processes most used for the extraction of silver and gold from their ores are the smelting of the ores with copper ores to matte and eventually blister copper, followed by electrolytic refining of the latter, or smelting with lead ores, followed by desilverization of the resulting lead bullion, cupellation of the rich lead, or electrolytic refining of the same. In all of these cases the silver or gold is a comparatively minute constituent of the ore, intermediate products and final metal, so that the metallurgy of silver or gold, after these methods, up to the production of impure silver or gold, or silver or gold bullion, is practically the metallurgy of copper or lead—both of which subjects we have considered at length.

When we obtain products in which the silver or gold is the chief constituent, we approach a condition in which calculations upon the precious metal contained may be based, but here again there are not the same conditions of economy so prominent in the metallurgy of lead or copper. It does not matter greatly, for instance, whether we use 50 cents' worth of one fuel or a dollar's worth of another in melting 1,000 ounces of silver worth over $500; the question of which fuel is the cleanest or most convenient is of greater importance than the costs of the fuels.

The object of this introduction is to show that, until it comes to handling nearly pure silver or gold, close calculations as to amounts of reagents, running of furnaces, etc., are not practicable for silver or gold *per se*.

Electrolytic Refining of Silver Bullion.

The parting of gold and silver by acids is rapidly giving place to the cleaner and less expensive electrolytic separation. The bullion may be of very variable composition. The following analyses of two samples give an idea of this variation:

	Cupelled Silver.	*Impure Silver.*
Ag	98.69	74.08
Pb	1.09	3.71
Cu	0.12	20.23
Fe	0.09	1.01
Au	0.0023	0.05

The electrolytic refining proceeds easiest with the nearly pure silver, because the impurities going into solution accumulate much more slowly, and the solution therefore requires purifying less frequently. On the other hand, the solution of a large amount of copper, iron or lead adds electromotive force to the circuit, since silver only is deposited, and thus decreases the electrical work to be done.

Problem 126.

Two varieties of silver bullion are refined electrolytically, carrying

	No. 1.	*No. 2.*
Ag	98.69	74.08
Pb	1.09	3.71
Cu	0.12	20.23
Fe	0.09	1.01
Au	0.01	0.05

The slimes from each carry in percentages:

	No. 1.	*No. 2.*
Ag	60	55
Pb	10	5
Cu	5	15
Fe	3	5
Au	22	20

In each case all the gold goes into the slimes. A current density of 200 amperes per square meter of electrode surface is used, and the plates are 2 centimeters thick. Specific gravity of No. 1, 10.15; of No. 2, 9.79. There is anode scrap equal to 12 per cent of the weight of the plates. The working space between the electrodes is 4 c.m., total current 220 amperes per tank, specific resistance of electrolyte 20 ohms. Deposited silver, 19.85 kg. per tank per day.

Required:

(1) The ampere efficiency of the deposition of silver.

(2) The weight of anode corroded in a tank per day.

(3) The deficit in weight of silver in the electrolyte in each tank per day.

(4) The electromotive force contributed to the circuit by the solution of impurities in the case of each bullion.

(5) The total drop of potential across each tank, adding 10 per cent for loss in contacts.

(6) The horsepower-hours required per kilogram of silver deposited in each case.

Solution:

(1) Silver deposited theoretically by one ampere per day, $0.00001035 \times 108 \times 60 \times 60 \times 24 = 96.58$ grms.

220 amperes deposits $96.58 \times 220 = 21{,}248$ "

$= 21.248$ kg.

$$\text{Ampere efficiency} \frac{19.85}{21.248} = 0.934 = 93.4 \text{ per cent.} \quad (1)$$

This means that 6.6 per cent of all the silver which the current is capable of depositing is prevented from depositing by the nitric acid present, forming $AgNO^3$. The electrolyte is silver nitrate with copper nitrate, and contains always about 1 per cent of free nitric acid, which thus acts chemically upon the deposited silver (or acts to prevent its deposition to this extent, whichever way we wish to look at it).

(2) The weight dissolved, per 100 grams of anode corroded, is, assuming all the gold to appear in the slimes:

No. 1.

	Anode.	*Slimes.*	*Dissolved.*
Ag	98.69	0.03	98.66
Pb	1.09	....	1.09
Cu	0.12	....	0.12
Fe	0.09	....	0.09
Au	0.01	0.01	....

No. 2.

	Anode.	*Slimes.*	*Dissolved.*
Ag	74.08	0.14	77.94
Pb	3.71	0.01	3.70
Cu	20.23	0.04	20.19
Fe	1.01	0.01	1.00
Au	0.05	0.05	....

The amount of current necessary to dissolve these weights will be the sum of the current which would be necessary to dissolve each constituent separately. These will be found in ampere-hours by dividing each by its electrochemical chemical equivalent × 3,600.

No. 1.

		Ampere-Hours.
Ag	98.66 ÷ 0.001118 × 60 × 60 =	24.51
Pb	1.09 ÷ 0.00107 × 60 × 60 =	0.28
Cu	0.12 ÷ 0.00033 × 60 × 60 =	0.12
Fe	0.09 ÷ 0.00029 × 60 × 60 =	0.09
		25.00

No. 2.

Ag	77.94 ÷ 4.025 =	19.36
Pb	3.70 ÷ 3.856 =	0.96
Cu	20.19 ÷ 1.185 =	0.96
Fe	1.00 ÷ 1.044 =	0.96
		38.32

Since there is disposable 220 × 24 = 5,280 ampere-hours in a tank per day, there will be corroded the following weights of anodes per day in tanks containing Nos. 1 and 2, respectively:

$$\text{No. 1} \ldots\ldots 100 \times \frac{5{,}280}{25} = 21{,}120 \text{ Grams.}$$

$$\text{No. 2} \ldots\ldots 100 \times \frac{5{,}280}{38.32} = 13{,}779 \text{ "}$$

(3) There is dissolved in a tank, per day, the following weights of silver:

No. 1 anodes: 21,120 × 0.9866	= 20,837	Grams.
No. 2 anodes: 13,779 × 0.7794	= 10,739	"
Deposit in each tank	= 19,850	"
Surplus in No. 1 tank	= 987	"
Deficit in No. 2 tank	= 9,111	" (3)

(4) The heats of formation of the acid and salts concerned are:

(Ag, N, O^3, Ag)	= 23,000 cal.	= 213 cal.	per gram Ag.
(Pb, N^2, O^6, Ag)	= 98,200 "	= 474 "	" Pb.
(Cu, N^2, O^6, Ag)	= 81,300 "	= 1,278 "	" Cu.
(Fe, N^2, O^6, Ag)	= 43,900 "	= 784 "	" Fe.
(H, N, O^3, Ag)	= 48,800 "	= 48,800 "	" H

The heat balance per 100 grams of anodes No. 1 is:

Solution of Ag,	98.66 ×	213 =	21,015	cal.
" Pb,	1.09 ×	474 =	517	"
" Cu,	0.12 ×	1,278 =	153	"
" Fe,	0.09 ×	784 =	71	"
Heat evolved		=		21,756 cal.
Deposit'n of Ag,	93.99 ×	213 =	20,020	"
Liberat'n of H^2	0.06 ×	48,800 =	2,928	"
Heat absorbed		=		22,948 "
Heat deficit		=		1,192 "

Since this is per 25 ampere-hours [see (2)] and 1 ampere-hour at 1 volt = 860 calories, the voltage which this deficit of energy will absorb in the case of anodes No. 1 is:

$$1{,}192 \div 25 \div 860 = 0.06 \text{ volt.} \quad (4)$$

The similar calculation for anodes No. 2 gives per 100 grams corroded:

Solution of Ag,	77.94 ×	213 =	16,601	cal.
" Pb,	3.70 ×	474 =	1,745	"
" Cu,	20.19 ×	1,278 =	25,803	"
" Fe,	1.00 ×	784 =	784	"
Heat evolved		=		44,942 cal.
Deposit'n of Ag,	98.11 ×	213 =	20,897	"
Liberat'n of H^2	0.06 ×	48,800 =	2,928	"
Heat absorbed		=		23,825 "
Surplus heat		=		21,117 "
Voltage *generated*		=		0.98 volt. (4)

(5) Resistance of each element of electrolyte of 1 square c.m. area is 20 × 4 = 80 ohms. The current passing through this is 220 ÷ 10,000 = 0.022 amperes. The drop of voltage, due to the resistance of the electrolyte, is, therefore,

$$0.022 \times 80 = 1.76 \text{ volts.}$$

Adding decomposition voltage we have

In case of No. 1 anodes, 1.76 + 0.06 =	1.82	volts.
Add for resistance of contacts	0.18	"
Working voltage	2.00	" (5)
In case of No. 2 anodes, 1.76 — 0.98 =	0.78	"
Add for resistance of contacts	0.18	"
Working voltage	0.96	" (5)

(6) Horsepower required per tank:

$$\text{Anodes No. 1} \frac{220 \times 2.00}{750} = 0.59 \text{ hp.}$$

$$\text{Anodes No. 2} \frac{220 \times 0.96}{750} = 0.28 \text{ "}$$

Power per kilogram of silver deposited:

Anodes No. 1, 0.59 ÷ 19.85	= 0.020	hp.-days.
	= 0.48	hp.-hours. (6)
Anodes No. 2, 0.28 ÷ 19.85	= 0.014	hp.-days.
	= 0.34	hp.-hours. (6)

Problem 127.

The Wohlwill process for refining gold bullion operates with $AuCl^3$ solution, strongly acid with HCl. Design a plant for refining bullion having the analysis:

Au	60.3	Fe	2.2
Ag	7.0	Ni	2.0
Cu	6.5	Pb	7.0
Zn	15.0		

Assume the following data to start with:

Current density, 1,000 amperes per square meter.

Use ten tanks in series.

Tanks available, 500 m.m. × 500 m.m. × 300 m.m. deep, inside.

Electrodes about 4 c.m. apart.

Starting sheets 1 m.m. thick.

Anodes 20 m.m. thick.

Specific gravity of anodes 17.5.

Gold present in solution 50 grams per liter.

Specific resistance of electrolyte 5 ohms.

Specific gravity of the electrolyte 1.15.

Loss of electromotive force at contacts one-half the loss due to the resistance of the solution.

Anode products, $AuCl^3$, AgCl, CuCl, $ZnCl^2$, $FeCl^3$, $NiCl^3$, $PbCl^2$.

Required:

(1) The size and dimensions of electrodes and number in a tank.

(2) Current used and total voltage of the system.

(3) Gold deposited per day.

(4) Anodes corroded per day, assuming corrosion uniform.

(5) Deficit of gold in the tanks per day.

(6) If anodes are left in until 9/10 dissolved, how long will they last?

(7) If cathodes are removed every 24 hours, what is the average time of treatment?

(8) At 6 per cent per annum, what is the interest charge per kilogram of gold under treatment in the plant, gold being worth 72.9 cents per gram?

Solution:

(1) Allowing 1 c.m. clearance at the sides, the plates must not be over 48 c.m. in width across the tank. The electrolyte must not be nearer than 2 c.m. to the top of the tank, and the plates ought to be 8 centimeters above the bottom, to allow space for slimes to accumulate. The immersed depth of plates is, therefore, 40 c.m., and the superficial area 960 sq. c.m. on a side.

With spaces 4 c.m., anodes 2 c.m. thick and cathodes 0.1 c.m., using one more cathode than anode, we have the spaces equal in number to twice the anodes, and, therefore,

$$(2 \times \text{anodes}) + (\text{anodes} + 1)\ 0.1 + (2\ \text{anodes} + 4) = 50,$$

whence the number of anodes figures out 4.9. (1)

Choosing the nearest whole number, 5, there will be 6 cathodes, and the working spaces will be 10, and their width

$$\frac{50 - 5(2) - 6(0.1)}{10} = 3.94 \text{ c.m.} \qquad (1)$$

(2) Ignoring the edges of the plates, the working surface per tank is $960 \times 2 \times 5 = 9{,}600$ sq. c.m., and the current $9{,}600 \div 10{,}000 \times 1{,}000 = 960$ amperes. (2)

The voltage to overcome ohmic resistance is

$$5 \times 3.94 \times \frac{1{,}000}{10{,}000} = 1.97 \text{ volts.}$$

Add 50 per cent loss at contacts = 0.98 "

Sum = 2.95 "

The voltage corresponding to the chemical action occurring can be calculated from the energy of formation of the $AuCl^3$ decomposed minus the energy of formation of the salts formed. More simply, although not so logically, it may be derived from the voltages of decomposition of these compounds, allowing for the proportions of each formed and decomposed. These are:

(Au, Cl^3)	=	27,200 ÷ 3 ÷ 23,040	= 0.393 volt.
(Ag, Cl)	=	29,000 ÷ 1 ÷ 23,040	= 1,257 "
(Cu, Cl)	=	35,400 ÷ 1 ÷ 23,040	= 1.536 "
(Zn, Cl^2)	=	113,000 ÷ 2 ÷ 23,040	= 2.448 "
(Fe, Cl^3)	=	100,100 ÷ 2 ÷ 23,040	= 2.170 "
(Ni, Cl^3)	=	93,900 ÷ 2 ÷ 23,040	= 2.037 "
(Pb, Cl^3)	=	77,900 ÷ 2 ÷ 23,040	= 1.690 "

These are the voltages which would be generated at the anode in case each one of these salts was the only salt being formed. But, since we know the exact composition of our anode dissolved, we can calculate the corresponding voltage generated at the anode:

Au,	0.603 × 0.393	= 0.237 volt.
Ag,	0.070 × 1.257	= 0.088 "
Cu,	0.065 × 1.536	= 0.101 "
Zn,	0.150 × 2.448	= 0.367 "
Fe,	0.022 × 2.170	= 0.048 "
Ni,	0.020 × 2.037	= 0.041 "
Pb,	0.070 × 1.690	= 0.118 "
	Sum	1.000 "
Absorbed at the cathode		0.393 "
Total voltage generated		0.607 "
Absorbed in electrolyte and connections		2.95 "
Working voltage per tank		2.34 "
Total for the system		23.4 " (2)

(3) Au deposited by 960 amperes in ten tanks per day:

$$0.00001035 \times \frac{197}{3} \times 60 \times 60 \times 24 \times 960 \times 10 = 563.729 \text{ gr.} = 563.729 \text{ kg.}$$

(4) One gram of anode requires for its corrosion:

Au,	0.603 ÷ 197	÷ 3	÷ 0.00001035
Ag,	0.603 ÷ 108		÷ 0.00001035
Cu,	0.065 ÷ 63.6		÷ 0.00001035
Zn,	0.150 ÷ 65	÷ 2	÷ 0.00001035
Fe,	0.022 ÷ 56	÷ 2	÷ 0.00001035
Ni,	0.020 ÷ 59	÷ 2	÷ 0.00001035
Pb,	0.070 ÷ 207	× 2	÷ 0.00001035

= 0.01703 ÷ 0.00001035 = 1,645 amp. seconds.

Current available per day:

960 × 60 × 60 × 24 × 10 = 829,440,000 " "

Anodes corroded per day:

829,440,000 ÷ 1,645 = 504,220 grams.

= **504.220** kilograms (4)

(5) Gold deposited = 563.729 "

Gold dissolved = 504.220 × 0.603 = 304.045 "

Deficit in gold in the plant per day = 259.684 " (5)

(6) Weight of anodes:

960 × 4 × 17.5 × 5 × 10 = 3,360,000 grams.

= 3,360 kilograms.

One-tenth scrap = 336 "

Weight corroded = 3,024 "

Days to corrode them:

$$\frac{3{,}024}{504.22} = 5.93 = \text{practically } \mathbf{6} \text{ days.} \quad (6)$$

(7) Average time of treatment, removing one-sixth each day:

$$(1 + 2 + 3 + 4 + 5 + 6) \div 6 = 3.5 \text{ days.} \quad (7)$$

(8) Value of gold in plant is, in regular running, value of cathodes for all the time plus value of anodes for $3.5 \div 6 =$ 58 per cent of the time.

Value of cathodes:

$960 \times 0.1 \times 19.2$ (sp. gr. gold) $\times 6 \times 10 \times 0.729 =$ \$80,578

Value of gold in anodes:

$3{,}360{,}000 \times 0.603 \times 0.729 =$ 1,477,012

Average value of anode gold under treatment:

$1{,}477{,}012 \times (3.5 \div 6) =$ 861,590

Sum of cathode gold continually in stock and average value of anode gold under treatment:

\$80,578 + \$861,590 = \$942,168

Interest per annum at 6 per cent = 56,530

Interest charge per day = 155

Interest charge per kg. of anode refined:

\$155 ÷ 504.22 = \$0.31 per kg.

Interest charge per kg. of gold under treatment:

\$155 ÷ 304.045 = **\$0.51** per kg. (8)

THE VOLATIZATION OF SILVER AND GOLD.

It is known that both of these metals can be vaporized; it can easily be done in the electric arc. If they are placed in a vacuum, in quartz vessels, they show signs of metal vaporizing at 680° and 1,070°, respectively, although what vapor tension this corresponds to we do not exactly know, but we can surmise it to be a small fraction of a millimeter. If heated still higher in a vacuum, they show the phenomenon of ebullition, or boil, at 1,360° and 1,800°, respectively, although here again we do not know what pressure this corresponds to, except it is the pressure of the melted metals above the spot where the vapor commences to form beneath the surface, which might be 5 to 10 millimeters of melted metal, say 10 millimeters of mercury, if the bath of metal were shallow. From these data, obtained by Schuller, Krafft and Bergfeld, it is estimated that the boiling points of the two metals under atmospheric pressure are 2,040° and 2,530°, respectively, on the assumption that the temperature interval between first signs of vaporization in a vacuum and boiling in a vacuum is equal to the interval between the latter temperature and the ordinary boiling point. (This is said to be true of mercury.)

O. P. Watts has estimated the boiling point of silver and gold as 1,850° and 2,800°, respectively, meaning probably at atmospheric pressure; but his estimate is based on such assumptions that they cannot lay claim to as much accuracy as the data and estimates above cited.

If we go back to the very probable rule, that at equal fractions of the normal boiling points, expressed in absolute temperatures, metals have the same vapor tensions, we can compare silver and gold with mercury, whose vapor tension is known through a wide range, and get quite probable values for the vapor tensions of these metals through a large range of temperature. The following table is from nearly zero tension to about the temperature at which ebullition is noticeable in a vacuum:

Tension of Vapor. m.m. of Hg.	*Mercury. C°*	*Lead. C°*	*Silver. C°*	*Gold. C°*
0.0002	0	625	729	942
0.0005	10	658	766	987
0.0013	20	691	802	1,031
0.0029	30	724	839	1,075
0.0063	40	757	876	1,120
0.013	50	790	913	1,165
0.026	60	822	949	1,209
0.050	70	855	986	1,254
0.093	80	888	1,023	1,298
0.165	90	921	1,059	1,343
0.285	100	954	1,096	1,387
0.478	110	987	1,133	1,432
0.779	120	1,020	1,169	1,476
1.24	130	1,053	1,206	1,520
1.93	140	1,086	1,243	1,565
2.93	150	1,119	1,280	1,611
4.38	160	1,151	1,316	1,654
6.41	170	1,184	1,353	1,699
9.23	180	1,217	1,390	1,743

Inspecting the above table, we see that apparently about 0.0002 m.m. of mercury tension is sufficient to make a metal show signs of vaporization. The corresponding temperatures at which silver and gold show 0.0002 m.m. tension are, from the above table, 729° and 942°, respectively, whereas it is said to have been observed for these metals at 680° and 1,070°. The divergence is not wide, considering the lack of exact data involved.

Mercury is said to show ebullition in a vacuum at 180°, lead at 1,250°, silver at 1,360° and gold at 1,800°. From the above table we see these metals having the same vapor tension at 180°, 1,217°, 1,390° and 1,743°, respectively. The agreement is encouraging.

The table in continuation is for temperatures from those causing ebullition in a vacuum to those required to boil the metals at atmospheric pressure:

Tension of Vapor. m.m. of Hg.	*Mercury. C°*	*Lead. C°*	*Silver. C°*	*Gold. C°*
9.23	180	1,217	1,390	1,743
14.84	190	1,250	1,427	1,788
19.90	200	1,283	1,463	1,832
26.35	210	1,316	1,500	1,877
34.70	220	1,349	1,537	1,921
45.35	230	1,382	1,574	1,965
58.82	240	1,415	1,610	2,010
75.75	250	1,448	1,647	2,055
96.73	260	1,480	1,684	2,099
123.	270	1,513	1,720	2,144
155.	280	1,546	1,757	2,188
195.	290	1,579	1,794	2,233
242.	300	1,612	1,830	2,277
300.	310	1,645	1,867	2,322
369.	320	1,678	1,904	2,366
451.	330	1,711	1,941	2,410
548.	340	1,744	1,977	2,455
663.	350	1,777	2,014	2,500
760.	**357**	**1,800**	**2,040**	2,530

* For tensions of metallic vapors over 1 atmosphere, such as may easily occur in high temperature work, particularly in electric furnaces, the following data may be useful:

Tension of Vapor. Atmospheres.	*Mercury. C°*	*Lead. C°*	*Silver. C°*	*Gold. C°.*
1.0	357	1,800	2,040	2,530
2.1	400	1,951	2,197	2,722
4.25	450	2,116	2,380	2,945
8.	500	2,280	2,564	3,167
13.8	550	2,445	2,747	3,390
22.3	600	2,609	2,931	3,612
34.0	650	2,774	3,114	3,835
50.	700	2,938	3,298	4,057
72.	750	3,103	3,481	4,280
102.	800	3,267	3,665	4,502
137.5	850	3,436	3,848	4,725
162.	880	3,525	3,958	4,858

The last table may not be of much immediate practical value, but it is interesting scientific information. The preceding tables are, however, technically and commercially important. They point particularly to the wastefulness of melting silver or gold in open furnaces where furnace gases pass over the metal. Such gases, at temperatures above 700° for silver and 950° for gold, *i. e.*, even passing over *unmelted* metal, can cause volatilization and loss of weight, because they evaporate the metal on exactly the same principle that a current of dry air evaporates ice or water. They also explain why silver volatilizes with lead in the cupellation operation. At 1,000° C. lead has a vapor tension of about 0.62 m.m. of mercury, and silver about 0.07 m.m., and, therefore, a considerable loss of silver is sure to occur with the lead vapors passing off. Gold at the same temperature has only 0.0007 m.m. tension, and, therefore, proportionately less of it is lost, say only one-fiftieth as much as the silver loss, reckoning from the proportionate tensions and the relative densities of the two vapors.

In calculating such metallic vapor losses it is important to remember that the metals are monatomic when in the state of vapor, and that the molecular weights of their vapors are simply their atomic weights. The hypothetical weight of a cubic meter of such metallic vapor at standard conditions, 0° C. and 760 m.m. pressure, is therefore,

$$0.09 \text{ kg.} \times \frac{\text{atomic weight}}{2},$$

and from this theoretical datum the weight of *any* volume at *any* temperature and *any* tension can be calculated.

Illustration: Calculate the weight of silver vapor contained in 1 cubic meter of furnace gases, if saturated with silver vapor and at 1,100° C.

Solution: Since the tension of silver at this temperature is 0.28 m.m., the question resolves itself into this: What is the weight of 1 cubic meter of silver vapor at 1,100° and 0.28 m.m. pressure? One cubic meter at standard conditions would be $0.09 \times (108 \div 2) = 4.86$ kilograms; therefore, at these given conditions, it contains:

$$4.86 \times \frac{273}{1{,}100 + 273} \times \frac{0.28}{760} = 0.0035 \text{ kg.}$$
$$= 3.5 \text{ grams.}$$

It is true that the silver vapor, being heavy, mixes slowly with the furnace gases, but, nevertheless, the gases rushing over and coming in contact with the silver may become nearly saturated with this vapor, and carry considerable away. In the Bessemerizing of copper matte to blister copper, by blowing air directly through it, as much as 30 per cent of all the silver present may be thus vaporized from the bath as soon as the silver has taken the metallic form.

Every smelter and refiner of the precious metals should be familiar with these facts, and draw conclusions from them useful to the conduct of his business.

The specific heat of these metallic vapors is 0.225 per cubic meter (calculated to standard conditions), and the latent heat of vaporization is approximately twenty-three times the normal boiling point expressed in absolute temperature for one atomic weight of the metal—as explained in Part I. of these calculations:

For silver and gold we would have the latent heats:

Ag, 23 (2,040 + 273)	= 53,200	Cal. per	108 kg.
	= **493**	"	1 kg.
Au, 23 (2,530 + 273)	= 64,470	"	197 kg.
	= **327**	"	1 kg.

The above latent heats of vaporization are for boiling at normal atmospheric pressure; for vaporization at other pressures and corresponding temperatures, correction must be made for the difference in specific heats of the metallic vapor and liquid metal.

The next instalment of these calculations will deal with the metallurgy of zinc, mercury and cadmium.

Notes on Metallurgy and Electrochemistry in Great Britain.

(By Our Special Correspondent.)

The Aluminium Situation.

An extraordinary general meeting of the shareholders in the British Aluminium Co., Ltd., have resolved to split their £10 conversion shares into two shares of £5 each, one to be a 7 per cent preference share and the other an ordinary share.

In view of the collapse of copper prices, the remarks of Mr. J. D. Bonner, the chairman, are of considerable interest. He said they were all no doubt aware of the demoralization of the metal markets of the world last summer, consequent on the slump in copper and the serious fall in metal prices generally, which brought to an abrupt termination the little boom in aluminium. Notwithstanding, it was estimated that the profits in 1907 would not fall materially below the £153,000 which they made in the previous year. They brought forward over £34,000 from 1906, so that they would have a very large disposable balance. It was their intention to deal with this upon the same conservative lines that they had proceeded upon in recent years, and after making a large appropriation to reserve fund, etc., and paying 7 per cent upon their ordinary shares, to carry forward an amount somewhere in the neighborhood of £50,000. They expected this year, now that they had started producing at the works at Leven, and at the Norwegian works, to produce about twice as much aluminium as they did last year. Although the price was at present only about £100, yet, if they succeeded in disposing of the whole of the increased production, which he was hopeful of doing, there should not be any material shrinkage in their profits, especially as some increase could be confidently counted upon for their investments. At all events, they had a larger tonnage of aluminium sold for forward delivery than ever before.

They had suffered an irreparable loss by the death of Lord Kelvin. Lord Kelvin was always keenly interested in the aluminium industry, and rendered eminent services in connection with its introduction by the company into this country. They who had been associated with him in its development and had had the benefit of his splendid intellect, could not but regret that they would lose the advantage of his guidance. Fortunately Mr. Morrison, with Lord Kelvin's full approval, became technical adviser jointly when Lord Kelvin was still with them. Their company was not merely an aluminium and manufacturing company, but was also a great power company, which in almost the immediate future, when all their great power schemes were completely developed, would have at its command something like 60,000 hp. They had had the advantage of their Foyers power for some years. Their Norwegian power was not so important, but it was a very cheap one. The Leven power, which was their largest, was, on account of its uniformity and location, one of the finest powers in the world. At Loch Leven they were building what was practically a small harbor, so that steamers of large tonnage could be able to approach at all times to within a few hundred yards of the works. Cheap freights were thus assured for all materials required, as well as for the material produced. They were also proceeding with the building of a village to give accommodation for 6,000 to 8,000 people, who would be necessary for the utilization of the power. They had a very valu-

able asset at Leven and were looking forward to the time when the large sum which they had expended upon it became productive, for they were not even taking credit for the interest during the constructive period, although authorized to do so under their Parliamentary powers. The scheme was costing materially more than they originally anticipated, and was taking longer to finish. This had caused great disappointment to the directors, as they had to promote a bill in this session of Parliament for an extension of time to complete the works. A year ago he mentioned that they were quite alive to the possibility of the demand for the prices of aluminium proving insufficient to warrant their employing in its production the whole of the power they had in prospect when it first became available. At any rate, for some years they would have to utilize the Orsieres power for other production, and at the present time negotiations with a Continental electrochemical company were in progress for that end. The shareholder would be prepared to hear that, in consequence of the large expenditure they incurred, they would want more money; but they still had over £300,000 to receive in respect of their last issue of conversion shares. They would, however, take advantage of any favorable opportunity to issue the £200,000 6 per cent preference shares they agreed to last spring; these formed part of a total issue of £300,000 6 per cent preference shares, of which £100,000 were placed some years ago, and they had behind them £1,000,000 of junior capital. Any other capital required would be raised by rearranging and enlarging the debenture debt and capital would stand at just over £2,000,000, the greater part of which was yet to become profit-earning. They would not only have this 60,000 hp., but other assets of great value. They owned the estate and village of Foyers, the village of Leven, their valuable and important French Bauxite investment, their carbon works and aluminium works at Larne, which cost over £100,000, and their large rolling mills in Staffordshire, which, owing to increasing demands for sheets and other manufactured products, they were compelled to still further enlarge. The only intangible asset in their balance sheet was good will, which had been reduced to £93,000, and which would be further reducible by the last year's profits, and would be gradually wiped out altogether. Their assets were not only valuable, but they might be counted upon to yield an income sufficient to assure them very substantial dividends.

BRITISH ELECTROCHEMICAL PATENTS EXPIRING IN 1908.

According to my usual custom I give herein details of inventions patented in 1894, which, having survived their full term, expire this year.

No. 835. Hargreaves and Bird.—"Improvements in the construction of electrolytic apparatus and in the application thereof in oxidizing, chlorinating and analogous processes."

This relates to the treatment of sewage, paper pulp, etc., requiring to be subjected to oxidization, chlorination, etc., and embraces the employment of apparatus constructed on the principle of Spec. No. 18,871, 1892.

For oxidation of sewage in which Cl. is present, for example, a series of cells may be used, the sewage flowing through each in turn, walls of cell composed partly or wholly of a permeable material in conjunction with a cathode of wire gauze or perforated metal; immersed in sewage is an anode of carbon, anode is made to divide cell into flow and return passages, cell may be enclosed in a chamber through which cold or hot air or steam circulates. Cl. liberated at anode combines with H in organic matter and forms HCl., O being liberated; HCl immediately decomposes, H being liberated from cathode and Cl regenerated.

Where direct oxidation is required H_2SO_4 or HNO_3 or salts from which they are derived may be added to the material under treatment. For bleaching paper pulp NaCl is employed instead of air acid.

It is further claimed that the apparatus may be used for bleaching cloth with the addition of guide rollers, and may also be used in the preparation of aniline dyes and organic acids, etc.

No. 9,285. Kellner.—Is entitled "Improvements in or relating to electrodes and method of manufacture."

This invention has for its object the construction and arrangement of electrodes, which can be made of any desired size and of any conducting material capable of resisting the action of the ions, and which, at the same time, constitute a perfectly tight closure, and have also the great advantage that in consequence of the "point-action" which takes place by their use, they can be worked at a much greater current density than other electrodes.

No. 12,221. Acheson.—Is entitled "Improvements connected with electrical furnaces," and its object is an improved construction and arrangement of mechanical parts of furnaces for the purpose of utilizing the current more economically and thus securing a cheapening of the product.

One of the objects of the invention is to provide a furnace wherein the current is restricted to a great extent to a cone in its passage through the furnace, while the material to be operated upon is arranged in the furnace so as to receive the heat energy from the core in lines diverging from the direction of the path of the current in contradistinction to those furnaces in which the material being operated on is intermingled with the conducting medium.

Also the core is of a relatively lower resistance than that of the material being treated, so that little, if any, of the material being treated carries the current.

The core may be of various substances, solid or granular; granular carbon is preferable, the size of grain varying according to size of furnace; in furnace 8 feet in length and maximum energy 100 kw., the diameter of core being 10 inches, grains would be about 3/16 inch diameter.

No. 14,987. Solway.—Is entitled "Improvements in or relating to the separation of caustic alkalies from the liquors obtained by the electrolysis of alkaline salts."

In order to effect a separation of the caustic alkali from the chloride the mother liquor may be subjected to evaporation whereby, when the solution has reached a certain degree of concentration, the salt becomes insoluble in the caustic alkali and precipitates.

Instead of evaporating the mother liquor resulting from electrolysis, there is poured into the same a solution of caustic soda of about 40° Beaumé. Produced by a prior operation, this addition has the effect of causing the whole of the salt present in the liquor to be precipitated and produces a solution practically free from NaCl, and which can therefore be readily evaporated by the triple effect apparatus.

The quantity of liquid that can be thus obtained is very small; the greater portion remains as soft mud; if attempts be made to take out the separated salt, it is found to be impregnated with soda solution to such a degree that the result is nil. To overcome this the mixture of salt and caustic liquor is placed in a vessel provided with a double casing to enable it to be heated by steam, and with a false bottom for keeping back the solid portion and allowing only the liquid to pass through, the whole is heated to about 100° C., after which there is poured on top of the mixture a layer of saturated salt water of equal volume to the caustic solution. On opening a discharge cock at the bottom of the vessel a displacement of a molar nature is produced, the caustic solution is expelled in successive horizontal layers and is replaced by the salt water without any mixing taking place. By this means practically the whole of the caustic solution can be obtained without dilution, and a mother liquor is also obtained for a succeeding operation.

No. 14,988. Solway.—Is entitled "Improvements in electrolytic cells," and remarks that a great drawback of all electrolytic cells is their small output in relation to surface area, due to the resistance of the electrolyte. This invention has refer-

ence to the reduction of the resistance by the use of electrolyzing surfaces formed of very thin electrodes placed side by side instead of opposite to each other, or face to face, with intervening spaces as before. Thus, when using strips of platinum insulated on their two sides or surfaces, the strips are pressed together like the leaves of a book, so that only their edges serve as conducting surfaces. In this manner there may be built up a block or slab, which, when seen from one side, will show an alternating arrangement of conducting and insulating lines, constituting, it may be, a plane or flat surface, and forming what is termed an electrolytic table, even numbered strips being connected to one pole and odd strips to the other; the total section of each strip acts as a conductor, but only the edge acts in electrolysis; edge may be made of Pt, and remainder of a cheaper metal.

As electrolysis effected by this means takes place with great intensity, the liquid must be quickly renewed, the table may be inclined and liquid arranged to flow over in a stream; surfaces may be in tubular form and liquid subjected to pressure; or centrifugal action may be employed.

A description is also given of a system of grooved covers for separating the products of electrolysis.

No. 15,276. Kiliani and Others.—Is entitled "Improvements in, or connected with, diaphragms for electrolytic purposes," and points out that diaphragms are at present made either of clay or porcelain, etc., which offer a great resistance to the current; or of thin sheets of soft, flexible material, such as parchment or asbestos, which have not sufficient mechanical strength unless supported.

The invention consists of supporting the parchment or asbestos, etc., by compressing it between two parallel series of laths, bars or rods of acid-proof material, the ends of the rods being fixed in frames and the frames built up into receptacles, etc.

The most important commercially is No. 20,259, Kellner (amended specification), entitled "Improvements in electrolytic apparatus for decomposing metallic salts," which forms the basis of the Castner Kellner electrolytic alkali process.

This invention has reference to an apparatus for the electrolysis of alkaline salts with the aid of a stationary mercury cathode, in which the amalgams formed by the electrolytic action has its location changed from the decomposing chamber, in which it is produced, to a combining chamber, in which it is decomposed and the cation combined with water, an acid or other body, by the shifting of a partition which can be moved to and fro in the mercury and serves to separate the two aforesaid chambers from each other. This partition is made in the form of a bell closed at its lower edge by a mercury seal and enclosing the decomposing chamber so that the amalgam formed in the latter is caused by the shifting of the bell to have its location alternately on one side and on the other side of the bell without itself changing its position, and thus is caused to become situated in the combining chamber, whilst the mercury on the other side of the partition, which was previously situated in the combining chamber, effects the amalgamation of the metal that is being separated by the decomposition of the electrolyte.

No. 24,541. Kellner.—Is entitled "Method of, and apparatus for, effecting electrolysis." This invention is designed to provide means for enabling the complete decomposition of metallic chlorides to be effected electrolytically with the practically complete utilization of the electrochemical equivalent of energy by means of vertically arranged, extremely simple, durable and reliable apparatus, without the use of a porous diaphragm.

The mercury cathode is employed in the form of narrow strips, which are formed by a system of channels arranged in a helical or zigzag path around the anode, whilst they are being continually freed from the cation they have taken up in their course.

The cathode consists of a spiral channel circulating around a porcelain cylinder, the channel being of porcelain and formed in one with the cylinder containing mercury, which is pumped from the bottom to the top of the spiral and circulates around the cylinder to the bottom by gravity. The channel is also formed around the inside of the cylinder, and it is arranged so that the odd numbered convolutions of the helix are on the inner surface of the cylinders, while the even numbered ones are on the outside; the mercury passes from outside to inside by means of an opening in the cylinder wall.

Inside this cylinder there is situated an anode of cylindrical form, which is filled with salt in a solid state, to be decomposed; this dissolves and maintains the strength of the solutions. The whole is arranged in a vessel which contains the substance (water, or other fluid agent) with which the separated cation is to be combined, and which is closed by a cover having gas outlet and water-inlet pipes.

The containing vessel may be of iron and connected electrically to various points in the mercury channel, and also to the negative pole of the generator.

Some Recent Improvements in the Wright Mercury Electrolytic Meter.

A paper in the London *Electrician*, by H. Stafford Hatfield, is deserving of attention.

After summarizing the general arrangement and construction, the original Wright meter, nature of changes in the electrolyte, investigation for new electrolyte, improvement in construction and method of manufacture, these are treated of in detail.

General Arrangement.—The current is divided between a low-resistance shunt in parallel with a circuit comprising an electrolytic cell and a high resistance in series. About 1 per cent of the current passes through the latter. The cell—a small glass tube—contains a mercury anode, an aqueous solution of a salt of mercury and a cathode of any metal which will not amalgamate. On this the mercury is deposited, and falls in very minute drops into a graduated tube from which B. T. U. can be read. Further structural details are then described.

The Original Wright Meter.—Mr. Stafford proceeds to point out how this, although apparently accurate, developed faults which appeared to be in consequence of errors in the disposition of the electrolyte. He explains, at some length, the nature of the required corrections, which will, perhaps, be found interesting to chemists. The instrument has evidently been designed with much forethought in regard to its stability; and experiments with various electrolytes made, the conclusions from which are given in the footnotes.

Nature of Changes in the Electrolyte.—It is stated that the electrolyte containing 10 per cent of mercurous nitrate and 1.1 per cent of free acid is stable at ordinary temperatures in the presence of mercury, and a possibly new view of the interference of electrolysis with chemical action is foreshadowed. The footnote here is misleading [*Vide* "Elementary Chemistry"], and the use of the term "meta-stable" is very questionable. Moreover, the "balancing point" mentioned is the *alter ego* of the critical point of unstable equilibrium, and it would be well if some common system of nomenclature could be agreed on which would apply *mutatis mutandis* to all branches of chemical science.

The Physical Society's Annual Exhibition of Apparatus.

On Friday evening, Dec. 13, 1907, the Physical Society, at the Royal College of Science, South Kensington, an exhibition of various scientific apparatus—this being the third anniversary—to which members of allied societies were invited. The whole was of interest and value, and the following features attracted special attention:

The Cambridge Scientific Instrument Co., Ltd., exhibited a good selection of their widely known instruments; Callender & Griffiths' bridge being particularly worth attention by reason of the new features and improvements it presents. They also

exhibited a potentiometer designed for thermo-electric work, which appears to embody several improvements, especially in regard to homogeneity of structure as far as possible. The company also showed a D'Arsonval galvanometer, Nernst lamp and scale, an improved form of milli-voltmeter, a Duddell's patent sensitive thermo-ammeter, etc.

Messrs. Cassells had Reeves' patent distance measurer, described as a new instrument for measuring distances without calculation, a gradient telemeter level, and others which need not be specified.

Messrs. Crompton & Co's exhibit included a portable slide wire, having good points; a standard potentiometer of modern disposition; a portable voltmeter with self-contained resistances; a universal shunt box of the Ayrton-Mather type, and a portable pyrometer for boiler testing.

Messrs. Elliott Bros. exhibited Harrison's universal photometer. They also had a new pattern P. O. Wheatstone bridge; an improved meter bridge; a "Century" mains test set—most useful; a fault localizing bridge (Murray's loop test); latest P. O. pattern Wheatstone transmitter-receiver-perforator, and several galvanometers, etc., well deserving attention. Their new "Die Castings" require further elaboration, but their speed indicators will, no doubt, be very useful to those in charge of motor cars.

Messrs. Everett, Edgecumbe & Co., Ltd., also exposed a flicker photometer with inclined screen and an inkless synchronized recorder; the Hamilton multicellular electrostatic voltmeter; a frequency indicator of resonance pattern; a direct-reading resistance bridge; a combined standard ammeter and voltmeter, and a portable astatic wattmeter were also shown.

Messrs. Evershed & Vignoles, Ltd., exhibited high-range and low-range meggers deserving attention; a bridge megger for workshop use; a combined ammeter and voltmeter for direct currents, and a cell tester for accumulators.

Messrs. A. Hilger, Ltd., had their quartz spectrograph and specimen prints and enlargements; a large wave-length spectroscope, and the Fabry & Perst interferometer. This exhibit deserved especial attention.

Messrs. Ross, Ltd. This firm's most noteworthy feature was a photo-micrographic camera of new construction with Nernst lamp and standard microscope.

Messrs. Alexander Wright & Co., Ltd., displayed the "Simmance-Abady calortometer," an instrument designed for the purpose of continuously and automatically indicating and recording the potential energy of gas in calories.

I regret that considerations of space compel me to omit mention of other exhibits.

A Quiet Month.

From the literary point of view, January was, in English electrochemical and electrometallurgical circles, a singularly quiet month. No meeting of the Faraday Society was held. The Institution of Mining and Metallurgy concerned themselves with three papers of a purely geological nature. Sister institutions, such as the Civils and Mechanicals, did not touch upon metallurgical matters. Save for declining prices in the metal trades (where the unsettled condition of the shipbuilding industry is a depressing factor), and an important meeting of the shareholders in the British Aluminium Co., your correspondent has little to chronicle, save details of patents expiring this year. One or two are of great importance. Others, however, suggest that the unfit occasionally survive.

Market Prices for January.

Tin.—On Jan. 2 the price of tin was £120.15 per ton; it fell to £118.12 on the 3d, rose to £123.5 on the 7th, fell to £121.8 on the 8th, and with slight fluctuations rose to £126.5 on the 14th, falling to £123 on the 17th, rising to $125.12 on the 20th, falling again to £123.18 on the 22d, rising to £125.5 on the 24th; it reached £123 on the 28th.

Copper.—Has not shown any marked variation during January. Opening at £61 to £62 per ton, it rose to £62.15 on the 7th, and after a fall to £61.15 on the 8th, rose steadily until on the 15th £64.5 was reached, after which date it again fell to £62.15 on the 17th. Rising to £63.10 on the 20th, it fell to £61.8 on the 27th and reached £62 on the 28th.

Pig Iron.—Cleveland fell nearly continuously during the month. Opening at about 48/4 per ton, it rose to 48/10 on the 6th, fell to 48/2 on the 14th, rose to and remained at 48/6 during the 15th, from which it fell to 47/7 on the 23d, and rising to 47/10 on the 24th, reached 47/6 on the 28th.

Scotch Pig Iron.—The price of this was 57/6 per ton on the 6th of January, at which it remained steady until the 16th, falling to 57/- on the 7th; this price remained until the 22d; on the 23d it again fell to 56/9, at which it remained until the 28th.

Hematite.—Was 65/10 on the 31st of December, 1907, and by the 6th of January, 1908, had fallen to 64/6; it remained at this price until the 13th, fell to 63/10 on the 14th and remained steady until the 16th, from which date it fell to 61/10 on the 20th, remaining at this price until the 22d; it fell to 60/10 on the 23d, and was steady at this until the 28th.

English Lead.—Opened at about £15 per ton, and with the exception of a fall to £14.12 on the 9th, it remained at from £14.18 to £15.3 during the whole of the month.

The price of antimony for the end of the month was £35 to £36 per ton.

The chemical market at the end of the month was as follows: Ammonia sulphate, £12 per ton; copper sulphate, £23.5 per ton; bleaching powder, 35 per cent, £4.10; white caustic soda, 77 per cent, £11.2.6 per ton; benzole, 90 per cent, 7d. per gallon; carbolic acid liquid, 97 to 99 per cent, 1/1 per gallon; creosote, ordinary good liquid, 2⅝d. per gallon; naphtha solvent, 90 per cent at 160° C., 11d. per gallon; pitch, £1.1.6 per ton; shellac, £6.2.6 per cwt.

RECENT METALLURGICAL PATENTS

Iron and Steel.

Treatment of Chilling Iron with Nickel.—R. C. Totten (878,691, Feb. 11) describes the following process of treating chilling iron, *i. e.*, cast iron having a percentage of combined carbon (½ per cent or more) sufficiently large to give a chilled surface when cast in a chill mold. It is based on the affinity of nickel for the combined carbon, and on the fact that by varying the percentage of nickel to combined carbon the depth of chill may be regulated. In general the amount of nickel alloyed with the iron is made to follow approximately the proportion of combined carbon in the iron; for instance, if there is 1 per cent of combined carbon in the chilling iron, 1 per cent of nickel may be used. But by varying the proportion of nickel, the depth of the chill may be varied, since the nickel has a tendency to reduce the chilling properties of the combined carbon. For instance, if a chilling iron containing a certain percentage of combined carbon has added thereto, say, 1½ per cent nickel and produces a casting having a chill, say, 1 inch thick, then by using exactly the same iron and increasing the percentage of nickel, the depth of the chill will be decreased, or, by decreasing the quantity of nickel, the depth of the chill will be increased. This possibility of regulating the depth of the chill by varying the quantity of nickel used is of special importance in the utilization of scrap from car wheels, chilled rolls, etc. If such scrap is remelted and recast, there is a large increase in the proportion of combined carbon, giving an abnormally deep chill and rendering the article very brittle. By the use of nickel a chill of the desired depth is obtained and the strength and ductility of the nickel are greatly increased.

Hardening Cast Iron.—For hardening cast iron, G. H. H. Emett (878,053, Feb. 4) uses a compound consisting of 8 pounds flower of sulphur, 1 pound dry red lead, 4 ounces lamp black. These ingredients are ground in a mill, then run

through a sieve and well mixed together. For general purposes, 1 pound of the compound is added to 30 pounds of molten iron; for rock crusher castings (chilled) 1 pound of compound to 40 pounds iron; for sheaves (not chilled) 1 pound of compound to 25 pounds iron; and for sheaves with soft core 1 pound of compound to 30 pounds of iron.

Copper.

Treatment of Mine Waters.—To recover metals from mine waters, etc.—in general, from solutions containing the metal values in very small quantities—H. M. Crowther (877,912, Feb. 4) employs evaporation and filtration by capillary action, with precipitation of the metal in form of a solid compound. For instance, in the case of a liquid containing dissolved copper salts, like tailings water, which also contains much indissolved sediment in suspension, he proceeds as follows. A large shallow cone, open at the large end, is made of porous canvas or cloth and filled loosely to a depth of about 12 inches with broken bricks, cotton waste or other absorbent material, mixed with small bits of scrap iron (which are to act as a precipitant). The lower (small surface) point of the cone is then slightly submersed in the solution, when capillary action will draw up the copper solution and filter it at the same time. The great extension of evaporating surface results in increased concentration and the copper will be precipitated as metal by the iron, or copper salts will crystallize out. Another illustration of the process is as follows: A common absorbent building brick is saturated with a solution of sodium carbonate and partially dried out and its end is slightly submersed in the liquid containing a small percentage of a copper salt. In this case carbonate of copper will be precipitated in the pores of the brick.

Gold and Silver.

Slimes Filter.—Charles Butters, who is so well known through his intimate connection with the development of the cyanide process, patents (879,080, Feb. 11) the following process of treating slimes. While this process, as used at the cyanide plant of the Combination Mill, at Goldfield, Nev., has already been described at length and illustrated in our Vol. V., p. 88, it is interesting to sum up here the inventor's own description from his patent. In Fig. 1 the bottom of the tank 1 has an outlet 2, provided with a closure 3. In the upper portion a filter frame 6 is supported with the tubes 7 and 8. Tube 7 is deflected horizontally after it passes into the interior of the frame 6 and has perforations on its lower side (as indicated by dotted lines). Tube 8 passes to the bottom of frame 6 and is deflected horizontally and has perforations upon its upper side (as indicated by dotted lines).

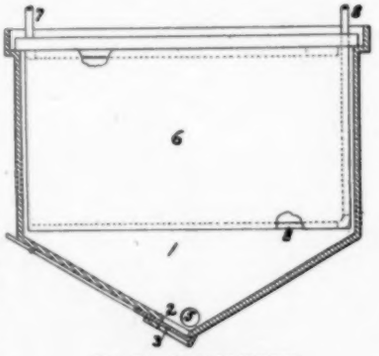


FIG. 1.—SLIMES FILTER.

Pipe 5 is provided for introducing and removing the slimes and solutions into and from the vat.

The slimes, after having been prepared and mixed with a quantity of lime or alkali, are discharged into vat 7 until the filter 6 is submerged. By exhausting the air from pipe 8, a vacuum is formed in the interior of the filter and maintained at as high a degree as the altitude of the locality where the process is carried on will permit. This causes a layer of the slimes to be deposited upon the surface of filter 6. The vacuum is then reduced to approximately 6 inches of mercury [sufficient to hold the layers of slime attached to the filtering surfaces]. The [balance of the] slimes is now discharged from vat 1 and the latter filled with cyanide solution. The vacuum is then again increased to the maximum, whereby the cyanide solution is drawn through the cakes of slimes. This is followed by again reducing the vacuum and discharging the cyanide solution from the vat into a receptacle where it can be stored for future use. The vat is next filled with water and the vacuum increased, whereby the remaining values in the slimes are withdrawn through the filter. The final operation consists in admitting air through pipe 8, and water through pipe 7 into the interior of the filter, whereby the cake of slimes is discharged therefrom. The exhausted slimes may be discharged from the tank by opening the closure 3. In localities where water is plentiful, the cake may be discharged without the use of air.

Filter.—The Ridgway filter has already attracted considerable attention. Those interested in it will find the details of construction described in a recent patent granted to George Ridgway, of Kalgoorlie, Western Australia (877,000, Jan. 21). The general idea of the filter is indicated by the first claim which refers to "a device comprising in combination a plurality of tanks arranged in circular order, a filter, a frame therefor provided with a roller, a track surrounding said tanks and provided with raised portions, said track being adapted for engagement by said roller to support said frame and raise and lower said filter out of and into said tanks, and means for moving said filters abreast of said tanks."

Aluminothermic Method.

Modification of Thermit Process.—K. A. Kuehne has formerly proposed to modify the well-known Goldschmidt process of reducing refractory oxides by means of powdered aluminium in so far as to use a mixture of aluminium with chlorates and perchlorates instead of pure aluminium. This he has recommended for the production of pure metals or metalloids in fused state, which cannot be thus obtained by reduction with aluminium alone. He now (878,210, Feb. 4) states that: instead of the chlorates and perchlorates he may employ other substances which easily give off oxygen, such as peroxides. In the original Goldschmidt process itself, barium peroxide is used as ignition powder. But Kuehne proposes to use the peroxide in larger quantities, *i. e.*, to use a mixture of aluminium and peroxide. Barium peroxide, lead peroxide and sodium peroxide may be used; in the same manner, persulphates, like sodium persulphate, may be employed. In order to get a highly fluid slag, so as to collect all the reduced metal on the bottom of the crucible, fluorspar, lime and the like are added.

Productions of Metals or Alloys from Refractory Compounds.

Phosphides as Reducing Agents.—F. von Kuegelgen and G. O. Seward (878,966, Feb. 11) propose the use of calcium phosphide, aluminium phosphide, iron phosphide, etc., as reducing agents. For instance, the reduction of chromium from chromic oxide is carried out by means of calcium phosphide according to the equation

$$8Cr_2O_3 + 3P_2Ca_3 = 3P_2O_5 + 9CaO + 16\,Cr,$$

both calcium and phosphorus acting as reducing agents. On the other hand, if iron phosphide is used, then the reaction is

$$5Cr_2O_3 + 6PFe_2 = 3P_2O_5 + Cr_{10}Fe_2$$

ferrochrome being produced. In this case the phosphorus alone acts as reducing agent. The heat of reaction is very different in different cases and in many cases the heat of reaction will have to be supplemented to a greater or less degree by other heating. In some cases the reaction will continue by the heat of the reaction after being started by the supplementing heating.

High Temperature Burners.

Air-Acetylene Burner.—John Harris, of Cleveland, Ohio, has formerly patented an air-acetylene burner (as distinguished from the oxy-acetylene burner), in which air and acetylene gas are thoroughly mingled in a mixing tube and the mixture ignited at the outlet end of the tube. The expanded burning mixture is prevented from dying away or blowing out as the air pressure is increased. However, this method seems to have met with some difficulties, since in his latest patent (878,461, Feb. 4) Harris modifies this design and provides a supply of oxygen at the base of the air-acetylene flame so as to increase the intensity of the flame and assure its adherence to the end of the mixing tube.

Cutting Metals.—In our Vol. V., p. 308, an illustrated article by M. U. Schoop was published on a new art of cutting metals, which is essentially based on the use of the oxy-acetylene or oxy-hydrogen or oxy-illuminating gas burner with an additional small tube supplying separately oxygen for burning and cutting the metal. A special burner for this purpose is the object of a patent of E. Ganthier and C. Rodrigues-Ely (874,666, Dec. 24, 1907), in which the quantities of gas are led in several independent streams to the work to be cut. How this special burner works out in practice we do not know. But it is a fact that the art of cutting metal plates by burners of this general type is finding considerable applications and great success in Europe, while it is still almost unknown in this country.

Regenerative Furnace.

Reversing Valve.—John B. Nau (878,306, Feb. 4) patents a reversing-valve system for regenerative furnaces, shown in Fig. 2, where *a* is a vertical section, *b* a section on line I-I, and *c* a plan view on line II-II. The valve system is enclosed within a metal casing 1, set directly over and surrounding flue openings, of which 2 leads to the left-hand regenerator, 3 to the smoke-flue, and 4 to the right-hand regenerator. The casing 1 is divided into three compartments, of which the lower ones 5, forming the valve chamber, are separated by a partition 6 in such a way that each chamber 5 will enclose one regenerator and one smoke-flue opening. Through their top partition each chamber 5 communicates by means of an opening 7 with the third compartment, the gas or air chamber 8. Each opening 7 is located directly opposite one of the smoke-flue openings 3. The gas chamber 8 is provided in its roof with a gas inlet opening 9 and at its two ends with cleaning doors 34.

Each valve chamber 5 is provided with a reversing valve 10, that by means of one or more hollow or solid spindles 11 can be moved up and down between its upper valve seat 12 and its lower valve seat 13. The upper valve seat 12 placed around and below opening 7 is made of a hollow-walled, water-cooled shell. The lower water seal is formed by a water trough 13, surrounding the smoke-flue opening 3. In order to prevent the passage of gas from one chamber to the other, a flange 35 is provided under partition 6. It reaches to a certain depth into the water below. The circularly-shaped reversing valve 10 is formed of a partition 14, surrounded on its rim by a water trough 15, normally filled with water to the level of the overflow 16. The removable iron ring 18, which is bolted to the circular flange 17, is meant to receive the first impact of the flame, so that the valve proper is protected against deterioration and possible cracking.

The valve is operated and regulated by means of the wheel 23. When the two valves are placed at the same level in their intermediate positions, they form both water seals with their upper valve seats, but not with their lower ones, thereby effectively preventing gas from entering the furnace, and yet leaving below free communication between the regenerator flues and the smoke-flues. With this arrangement of the valve system the two ends of the furnace can be, with the ordinary operation of the valves, put in communication with the smoke-stack, without in any way emptying the lower water seal of its water and without admitting any gas to the valve. When starting the operations of the valves from their intermediate positions, one valve will move upward the same amount that the other one will move downward. Of course, when the latter valve has reached its lowest position, a sufficient passage will have been established between itself and its upper valve seat for the necessary amount of gas to enter the furnace. But meanwhile the other valve, being placed in its upper position, will have opened a much larger passage for the products of combustion to pass between the valve and it lower valve seat on their way to the smokestack. Thus an excellent draft is always assured, whatever the positions of the valves. Under these circumstances it is possible to regulate the admission of gas to the furnace with the valve itself, instead of doing it with a valve controlling opening 9, as is done in other systems. Hence, when using the valve system with gas, the regulating valve with all its accessories, controlling opening 9, can

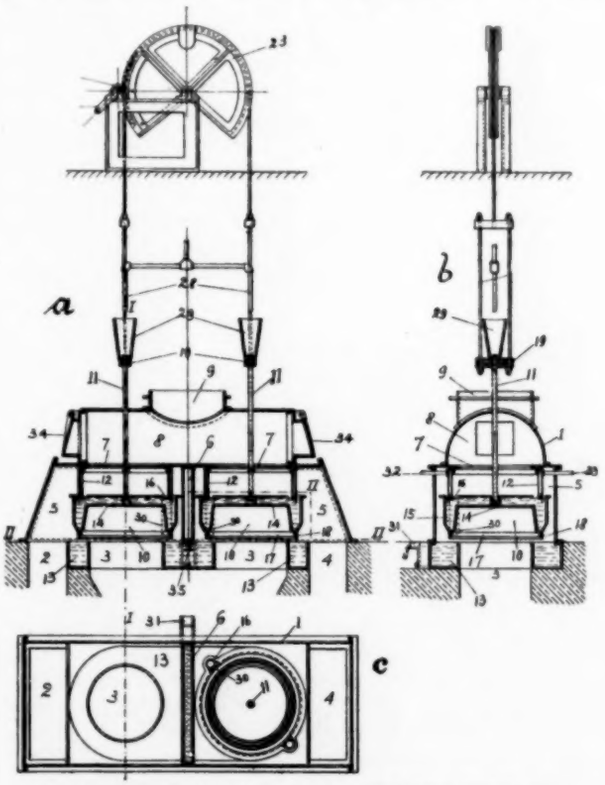


FIG. 2.—REVERSING VALVE FOR REGENERATIVE FURNACES.

be omitted. When using it with air, the whole gas chamber 8 with all its parts, such as gas inlet opening 9, cleaning doors 34, etc., can be omitted altogether. The outside air will then enter directly through that opening 7 which is kept open.

Cement.

Pulverizing Limestone.—In ordinary practice of cement manufacture the limestone is first crushed and then ground to the desired fineness. L. K. Forsythe (878,515, Feb. 11) endeavors to reduce the cost of this method by heating the rock to about 400° F. (which is below the temperature at which CO_2 is driven off). By then plunging the limestone into water, or by throwing water on the same, the limestone is rendered very pliable, so that it can be easily crushed and ground, the output of the mills being greatly increased.

Induction Furnace.—An excellent illustrated summary of the different designs of electric induction furnaces was recently given in a paper of Chief Engineer Victor Engelhardt before the Berlin Electrical Society. On account of limitations of space, we reserve a full report of the same for our next issue.

SYNOPSIS OF PERIODICAL LITERATURE.

A Summary of Articles Appearing in American and Foreign Periodicals.

Fixation of Atmospheric Nitrogen.

Arc Between Refractory Oxides.—Experimental investigations on the fixation of atmospheric nitrogen have become quite fashionable in Germany, as will be seen from the following abstracts of several recent interesting papers. E. Rasch (*Zeit. f. Elektrochemie*, Oct. 11) discusses the oxidation of atmospheric nitrogen in an arc between "conductors of the second class" (magnesia, thorium oxide, etc.). In early experiments on this subject he had hoped this would become a new useful source of light, but he soon found that the nitrous fumes formed were a great disadvantage for a lamp. He gives formulas and a diagram for the amount of nitrogen oxide formed as function of the speed with which the air is passed through the arc. His results show a great intrinsic difficulty of carrying out the process to best advantage. To produce as much nitrogen oxide as possible with a given amount of electrical energy, it is necessary to pass the air with a very high speed through the arc, but then we get a very low concentration of nitrogen oxide in the gas mixture and the wet treatment of the latter becomes more difficult. The author does not think that on account of this fundamental difficulty it will be possible to develop in this way a really cheap process for the fixation of atmospheric nitrogen. He offers another suggestion on the basis of the following considerations: The formation of nitrous oxide ($N_2 + O_2 + 2 \times 21{,}000$ cal. $= 2NO$) requires theoretically 25 watthours per mol No. But the greater part of the energy of the arc is consumed for heating the unchanged portion of the gas mixture. Further, in the reaction with water ($2NO + 3O + aq = 2HNO_3\ aq + 73{,}000$ cal.) there are set free 36,500 cal. per mol NO, and this energy can hardly be recuperated for useful work. The suggestion which Mr. Rasch makes is to pass the air through a high-tension alternating-current arc playing in water, so that nitric acid is directly produced. Two arrangements for this purpose are described and illustrated. Other experiments were made with 220-volt direct current in different electrolytes. It was possible to form an arc in the liquid, the nitrogen of the air, blown through the liquid, being oxidized to nitric acid or nitrates without formation of gaseous nitrogen oxides. The experiments were only preliminary and could not be concluded, and the author suggests to others to continue them.

Is Oxidation of Nitrogen a Purely Thermal Effect or Not?—In order to investigate whether the fixation of atmospheric nitrogen by electric discharges through air is a purely thermal effect (like an electric furnace process), H. Lee and A. Beyer have made a long series of experiments, which are described in *Zeit. f. Elektrochemie*, Nov. 1, 1907. They compared essentially direct-current and alternating-current flames of equal energy consumption and used iron electrodes, platinum electrodes and Nernst filaments. The chief result is that the conditions under which the discharges occur which heat the air are of far greater importance than the question whether direct current or alternating current is used. But it is shown that the variable influence of the special conditions of discharge depends on the degree to which the supplied energy is consumed in the arc itself, so that the experiments are another proof of the theory that the oxidation of atmospheric nitrogen by electric discharges is purely a thermal effect.

Directly the opposite result is arrived at in a very interesting paper by F. Haber and A. Koenig, in *Zeit. f. Elektrochemie*, Nov. 15. For a time the hypothesis has been generally accepted as correct, that the only effect of the electric arc is to heat the gas mixture to a high temperature, at which the thermochemical equilibrium requires the formation of a certain amount of nitrogen oxide, so that, according to this view, the electrical energy is first changed into heat. Haber and Koenig, of course, do not deny that such an indirect effect—change of electrical energy into heat with subsequent oxidation of nitrogen—exists, but they point out and make it very probable that there is also a direct oxidation of nitrogen by the electric discharge, *i. e.*, a direct change of electrical into chemical energy. Berthelot's original statement that the silent discharge through air does not oxidize the nitrogen, has been proven to be wrong by Warburg and recently by Berthelot himself. If there is a direct change of electrical energy into chemical energy, this would be of very great importance for the industrial fixation of atmospheric nitrogen, since the essential requirement would no longer be to heat the air first to an extreme temperature and then to cool it suddenly. The higher the percentage of nitric oxide produced in the gas mixture the less satisfactory becomes the pure thermal hypothesis, because it leads to the assumption of very high mean temperatures in the arc and of exceedingly quick rates of cooling the gas mixture. As will be seen below, Haber and Koenig have succeeded in getting a gas mixture of more than 12 per cent NO; this would require, on the basis of the purely thermal hypothesis, a temperature of 4,600° C., and an enormous speed of cooling the gas from this temperature. But in Haber's and Koenig's experiments the gas mixture was passed at a slow speed through a stationary flame within a tube cooled from the outside with water. They used a pressure less than atmospheric pressure, in order to increase the free wave-length of the ions and the kinetic energy which the ions can accumulate in moving through the electric field. At the same time the flame column is broadened. Air or other mixtures of nitrogen and oxygen were sucked by means of a pump through a series of apparatus, among them the arc tube. The arc was produced by alternating current of a frequency of 50 periods, the 120-volt supply voltage being raised by a 4-kw. transformer to 5,000 or 10,000; the tubes in which the arc played were cooled from the outside with water. The chief results, obtained at a pressure of 100 millimeters, are given in the following table:

Original Composition of Gas Mixture.		*NO Produced in*
O_2 *Per Cent.*	N_2 *Per Cent.*	*Per Cents by Volume.*
20.9	79.1	9.8
48.9	51.1	14.4
44.4	55.6	14.3
75.0	25.0	12.77
81.7	18.3	12.1

On the basis of the purely thermal hypothesis it would be necessary to assume temperatures between 4,300° and 5,000° in the apparatus, which is a very improbable assumption. For various reasons it is probable that the mean temperature in the arc tube was below 3,000°. Haber finally concludes that the best results should be expected from the use of cold arcs.

Flaming Ring.—In our Vol. V., p. 492, we noticed already how Brion has modified the flaming-disc method of Birkeland and Eyde into a flaming-ring method with good success. A very full illustrated account of his laboratory research with the flaming ring may be found in *Zeit. f. Elektrochemie*, Nov. 29.

Industrial Electrochemistry.

Direct Current or Alternating Current for Carbide Furnaces.—This subject is discussed by H. Lee and A. Beyer in *Zeit. f. Elektrochemie*, Nov. 1. If an electric arc is operated in air between metallic electrodes, a much higher voltage is required with alternating current than with direct current, because with alternating current the arc is broken periodically and must be lighted again. It is essentially different in electric furnaces, like carbide furnaces, because the arc plays here in a highly heated gaseous atmosphere. Experiments of the authors show that with the same arc length the voltage is here the same for direct and for alternating current. The results in carbide manufacture are the same with direct or alternating current, under otherwise equal conditions. In laboratory furnaces direct current at 30 or 35 volts is advantageous. On an industrial scale alternating current is preferable, on account of its easier transmission and transformation, and the higher voltage (60 or 65 volts) is necessary, because in order to pass a large current one must have a voluminous arc of a certain fair length.

Industrial Electrolytic Electrolysis.—B. Neumann gives in *Zeit. f. Elektrochemie*, Jan. 17, a review of developments during the second half of last year. New electrolytic methods of the electrometallurgy of copper, bismuth, lead, nickel, tin, zinc, silver and gold are briefly described and critically discussed, mostly on the basis of patent specifications. Some notes on industrial developments are interesting. Thus it is stated that the Betts process for lead refining, after having been introduced into England, is now also to be used in a plant in Germany. A new method of making seamless copper tubes by electrolysis has been devised. While Elmore polishes the rotating copper cylinder by means of an agate, a German patent (175,470) proposes to polish the deposit and remove any gas bubbles by means of a powder of kieselgur (using 20 kg. per 180 liters). S. Cowper-Coles (English patent 13,972) proposes a method of rotation, using 1,500 to 2,000 r. p. m.

Edison Accumulator.—In *Zeit. f. Elektrochemie*, Nov. 22, J. Zedner makes some polemical remarks on Foerster's former paper (see our Vol. V., p. 465) concerning some special points of the nickel electrode, especially concerning the question whether in the first period of discharge of the nickel electrode Ni_2O_3 is the only active oxide. This has been claimed by Zedner, while Foerster has shown before and shows again in his reply in *Zeit. f. Elektrochemie*, Jan. 10, that the facts require the assumption of the existence of an oxide higher than Ni_2O_3 together with the latter in the nickel electrode during the first step of the discharge; he therefore maintains that between Ni_2O_3 we have NiO_2, probably in form of a solid solution of the latter in the former.

Theoretical and Experimental Electrochemistry.

Automatic Current Regulator.—In *Zeit. f. Elektrochemie*, Oct. 11, O. Sackur describes an automatic regulator for obtaining constant current with varying voltage. It is shown in Fig. 1. In the cell A water is decomposed between two large nickel electrodes, and the oxygen and hydrogen gas mixture escapes through the capillary tube B. Inside the cell A a pressure is produced which is proportional to the speed with which the gas escapes from B, and, therefore, also proportional to the current. The terminals *a* and *b* of cell A are connected with the terminals a_1 and b_1. In the sketch, S is the source of current, X is the apparatus in which the current is to be kept constant, G an ammeter, and W_1, W_2, W_3 adjustable rheostats. By regulating W_1 the current through G and X is first adjusted to the desired value. Then the tube F is raised or lowered until the mercury is just below the platinum point C, but does not actually make contact with it. Further, the screw E is so adjusted that it is just above the mercury surface without actually making contact. If now the voltage of S should fall and the current in X and in the cell A will decrease, the gas pressure in A will decrease and the mercury in the manometer tube will rise and will make contact with C, so that the branch circuit W_2 C D in parallel with W_1 is closed. The current through A G X will therefore increase, contact C is broken, etc. On the other hand, if the e. m. f. of S should rise, the mercury will make contact with the screw E, and the branch circuit D E W_3 is closed, so that the current in A G X decreases. Then the contact E is broken, etc. Some precautions are described which are necessary if the apparatus is to be used for a considerable length of time.

Rheostat for Laboratory Purposes.—In *Zeit. f. Elektrochemie*, Nov. 22, C. Fredenhagen describes a portable rheostat for laboratory purposes. It consists of twenty-one resistors connected in series and having an aggregate resistance of 85.25 ohms. These twenty-one resistors are divided into five groups, and in each group the resistance of one resistor equals

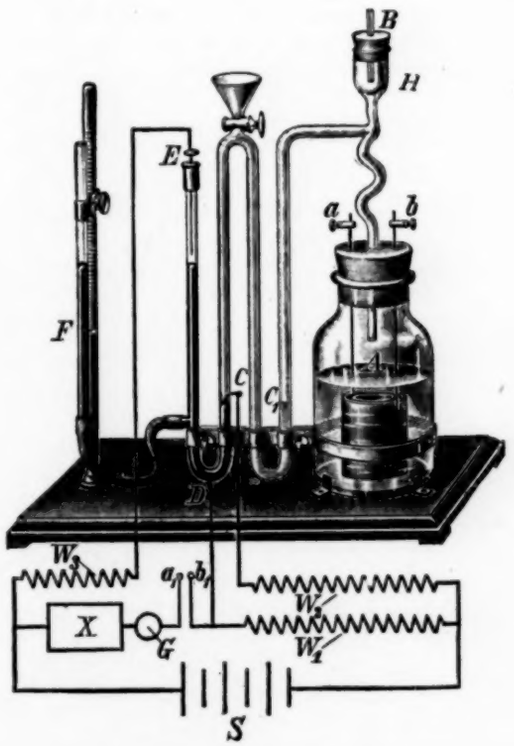


FIG. 1.—AUTOMATIC CURRENT REGULATOR.

the sum of the resistances of all resistors in the next group, as follows

Four resistances, each		16.00	ohms,	= 64.00	ohms.
" " "		4.00	"	= 16.00	"
" " "		1.00	"	= 4.00	"
" " "		0.25	"	= 1.00	"
" " "		0.05	"	= 0.25	"
				85.25	"

The last resistor in each of the first three groups is subdivided into four parts, the last resistance in each of the last two groups into five parts, which can be short circuited at will by special contact levers, one for each group. A main contact lever controls the whole system. This arrangement enables one to adjust the resistance in steps of 0.01 ohm between the limits of 85.25 ohms and 0.01 ohm. It is claimed that a rheostat of the same total resistance, but based on the decimal system, would require 70 per cent more single resistors.

Passivity of Iron.—In *Zeit. f. Elektrochemie*, Oct. 4, 1907, W. J. Müller and J. Königsberger describe experiments on the anodic and cathodic behavior of iron mirrors. They have found that active iron and passive iron have the same coefficient of reflection, and from this result they conclude that the passive state of iron cannot be due to an oxide film.

Passive State.—A. Loeb and M. Le Blanc, in former experiments on electrolysis with alternating currents, had found that Cu-electrodes, which had been annealed and quenched in alcohol, as well as Cu-electrodes which had been rubbed with emery paper, gave very much lower efficiencies than crystalline electrodes. Similar effects were observed with zinc and nickel. The "passive" state of these electrodes cannot be explained by an oxide film. In *Zeit. f. Elektrochemie* of Dec. 6, A. Loeb argues that there are reasons to assume that we have here to do with an "over-voltage" phenomenon which retards hydrogen evolution.

The Nature of Over-Voltage.—In *Zeit. f. Elektrochemie*, Oct. 18, E. Müller endeavors to show that Kaufler's attempted explanation of the nature of over-voltage (see our Vol. V., p. 467) is wrong. He maintains that the hypothesis of a very high hydrogen or oxygen pressure at electrodes, showing the phenomenon of over-voltage, is not superfluous, but on the contrary very useful.

Viscosity and Conductivity.—It has formerly been found that in many cases the conductivity of a solution is approximately inversely proportional to its viscosity. Fousserean has studied the behavior of fused electrolytes, and has found that in many cases the product of viscosity and conductivity is approximately constant. K. Arndt discusses this rule on the basis of experiments with fused mixtures of $NaPO_3$ and B_2O_3. His chief result is that in such ranges of temperature in which the salt is only soft, the above rule does not hold good, but that it represents a useful rule at higher temperatures when the salt is really fluid. In this connection he has derived the conclusion that fused electrolytes are completely dissociated into ions.

Analysis.—In *Zeit. f. Elektrochemie*, Jan. 3, a review is given by F. Foerster of the well-known recent advances made in electro-analysis with strongly circulated electrolytes. He acknowledges the great advantages and ease of E. F. Smith's methods of rapidly determining anions, and especially halogens, and alkali and earth-alkali earth metals. With this exception, however, he does not think that the field of applications of rapid methods with stirred electrolyte is wider than that of the methods using a stationary electrolyte, so that the sole advantage of the circulated electrolyte is the reduction in the duration of analysis. For certain industrial purposes this reduction in time is of great importance. But Foerster thinks that in other cases slow methods may do just as well, especially since they do not require special apparatus. He urges to pay in future more special attention to the development of slower methods with non-circulated electrolyte. He seems to hope much from the use of platinum-screen electrodes. With reference to this review, two brief papers are published by A. Classen and A. Fischer, with respect to some special points. A. Classen states that analysis with circulated electrolyte has been studied in his laboratory independently of American investigators. (In parenthesis it may be noticed that he mentions three names of Americans, but not E. F. Smith, who is evidently included in the abbreviation "u. a." "and others.") A. Fischer emphasizes the great advantage of rapid methods. In *Zeit. f. Elektrochemie*, Nov. 22, 1907, W. Neumann suggests an electrochemical method for qualitative detection of very small quantities of zinc. It is based on the deposition of zinc or a copper cathode from alkaline zincate solutions, and enables one to detect very small traces of zinc.

Valency.—In a theoretical note on the nature of valency in *Zeit. f. Elektrochemie*, Oct. 4, W. Peters makes the following suggestion: Within any molecule there are two counteracting forces; first, chemical affinity, which holds the atoms together on account of the attraction between the electric charges of the atoms, and, second, the oscillations of the atoms due to heat. At the absolute zero point of the temperature only the affinity acts. With rising temperature the atoms in a molecule begins to oscillate, and not only the amplitude of oscillations but the distance between the atoms increases with increasing temperature. "Valency is that part of the affinity of an atom which can manifest itself with respect to other atoms under the existing conditions of pressure and temperature." "If two ideal gases have equal numbers of atoms, equal molecular heats and equal Poisson coefficients at the same temperatures, then the sums of the valence numbers of their atoms are equal."

Valence of Hydrofluoric Acid.—G. Pellini and L. Pegoraro discuss in *Zeit. f. Elektrochemie*, Sept. 13, 1907, the question whether the molecular formula is HF or H_2F_2, and decide in favor of the former formula.

Electrolytic Reduction.—In *Zeit. f. Elektrochemie*, Oct. 25, 1907, H. Leiser describes a modification of the Oettel apparatus for direct reading the percentage figures in electrolytic reductions. The same issue contains a paper by the same author on the electrolytic reduction of tungstic acid.

Organic Chemistry.—In *Zeit. f. Elektrochemie*, Sept. 20 and 27, 1907, a review is given of recent progress in the electrolysis of organic compounds, electrolytic reductions and oxidations and other applications of the electric current in the field of organic chemistry.

Speed of Neutralization.—In *Zeit. f. Electrochemie*, Jan. 3, R. Abegg and J. Neustadt give a brief preliminary account of an attempt to measure the velocity of neutralization at low temperatures. Solutions of HCl and LiOH in ethyl alcohol were mixed, and the electric conductivity measured at temperatures of —80° and —100° C. The results of one experiment seem to indicate that, at the end of mixing, the neutralization was not got complete, but the results are not conclusive.

Radio-Activity.—In *Zeit. f. Elektrochemie*, Nov. 8, O. Hahn gives a good summary of the various investigations which have been published between May and October, 1907, on the radiation from radio-active substances and on radio-active substances themselves, also on Ramsay's observations on the transmutation of elements.

Atomic Weight of Chlorine.—The *Bulletin of the Bureau of Standards*, Vol. IV., No. 3, January, 1908, contains an account of W. A. Noyes and H. C. P. Weber's investigation of the atomic weight of chlorine. The value as found for the atomic weight of chlorine is 35.184, with a probable error of ± 0.0013, while the value obtained for the molecular weight of hydrochloric acid is 36.184, with a probable error of ± 0.0012. The combined average for the atomic weight of chlorine is 35.184, with a probable error of ± 0.0008, on the basis of hydrogen = 1. On the oxygen basis this value becomes 35.452 if H = 1.00762 (Morley) and 35.461 if H = 1.00787 (Noyes). The values for silver calculated from Richards' ratio and these two values are, respectively, 107,865 and 107,893. The mean values must be considered as most probable at the present time. These are **35.457** for chlorine and **107.88** for silver. In the same issue A. C. P. Weber describes a method of preparation of chloroplatinic acid by electrolysis of platinum black.

Steel.

Electric Steel Furnace.—The *Rivista del Servizio Minerario* gives an account of the results obtained with the Stassano electric steel furnace at Turin, which are summed up in the London *Electrician* of Jan. 24 as follows: In the works there

are in operation one revolving 200-hp. furnace, another of 1,000 hp. on the same system, and three stationary furnaces, two 100 hp. and the other 1,000 hp. The stationary furnaces, though lower in cost by a third, are only suitable for simple fusing operations, such as are usual in the ordinary Martin furnace. The revolving furnaces cost, respectively, $4,000 and $10,000, and are capable of producing 2.5 to 3 tons and 16 to 18 tons per 24 hours. The stationary 100-hp. furnace costs about $700, and produces about 1 ton every 24 hours. For working these furnaces three-phase currents at 21,500 volts are taken from the public mains, and are transformed down to 80 volts for the 100-hp. furnace, 100 volts for the 200-hp. furnace, and from 100 to 150 volts for the 1,000-hp. furnace. The 100-hp. furnace works on the single-phase system, and takes current up to 1,000 amps. The 200-hp. furnace is three-phase, while the 1,000-hp. has six electrodes and takes 1,800 amps on each phase.

Calcium Carbide and Acetylene.

A New English Carbide Plant.—In London *Electrical Engineering* of Nov. 28, we find some notes on a new plant for the manufacture of calcium carbide which is being erected at Thornhill, Yorkshire. The factory is being built for the Imperial Automatic Light Co., Ltd., and it is hoped that work will commence early in 1908. The works as at present designed are capable of an output of from 2,200 to 2,500 tons of calcium carbide per year, and, as already announced, the necessary electric power will be obtained from the Yorkshire Electric Power Co. The Imperial Automatic Light Co. claim that they can maintain a 2,500-candle-power acetylene flame for 1 hour at a cost of 9 cents. Their apparatus is said to be not only portable and clean, but absolutely safe in its automatic working. The cost of the plant for the 2,500 candle-power is given as $60, and a larger plant, with five jets, each giving 2,500 candle-power, costs about $92.00. The plant may also be used for welding by means of the oxy-acetylene flame. With respect to the safety of a good automatic acetylene lighting plant the writer of the note makes the following remarks: "At Strathyre, in the Highlands of Scotland, the writer has seen a plant in the Temperance Hotel of this small village. The plant is manipulated entirely by the proprietor, who is absolutely blind. He is able by feeling to manipulate the whole apparatus and describe its working. No accident has ever happened, and absolutely no smell can be noticed when the hotel is lighted up. One has only to notice how badly the bulk of our railway stations are lighted to wish that the railway companies would employ acetylene as a source of illumination in those stations where electric current is not conveniently available; it would probably cost very little more than the present gas and oil lamps, and in some cases it would be actually cheaper by a considerable amount."

Explosions in Chemical Works.

Static Electricity.—In an article of the *Chemiker Zeitung* of Dec. 18, M. M. Richter discusses the production of static electric charges by the friction due to belt driving. Such static charges are produced especially if some resinous material is applied to the belt to cause adhesion. By means of electroscope measurements, belt-potential difference of 13,000 volts were detected, the fly-wheel being negatively charged and the leather belt being positively charged. The effect is influenced largely by humidity in the air and on the belt. In chemical works, where the atmosphere contains vapors of oils and chemicals, dangerous explosions may be produced by sparks, due to such electrostatic charges. These electrostatic charges may be avoided if the belt is smeared with acid-free glycerine, since its hydroscopic nature keeps the belt moist and prevents the formation of static charges. This mixture, which may be applied by means of a sponge while the belt passes around, should be renewed weekly.

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

Electric Furnaces.

Vanadium.—F. M. Becket, 876,313, Jan. 14, 1908. Application filed July 29, 1907.

Vanadium is reduced from its sulphide directly by means of silicon and carbon, preferably in form of carborundum. The materials are mixed and heated in an electric furnace. The chief reaction which presumably occurs in the reduction of vanadium sulphide may be expressed by the following general equation:

$$4V_2S_7 + {}_7SiC = 4_2V + {}_7SiS_2 + {}_7CS_2.$$

By using a closed furnace and maintaining non-oxidizing conditions both the silicon and carbon disulphides may be collected, or they may be burned with air, to recover the sulphur contents as sulphur dioxide. For the production of an alloy of vanadium the metal to be alloyed with vanadium is added to the charge either as metal or as sulphide. The direct product is claimed to be very low in carbon and to contain merely traces as sulphur.

Molten Peroxides.—Hans Foersterling and Hector R. Carveth, 879,452, Feb. 18, 1908. Application filed March 6, 1907. Assigned to Roessler & Hasslacher Chemical Co.

Fused sodium peroxide is made in the apparatus shown in Fig. 1; *a* is a water-jacketed vessel tightly closed on the top by the cover *d*. By means of the electrodes *e* it is possible to heat the contents of the vessel, and that is the only purpose of the electric current. The tank *g* contains molten sodium, while through the pipe *j* air is delivered under pressure into

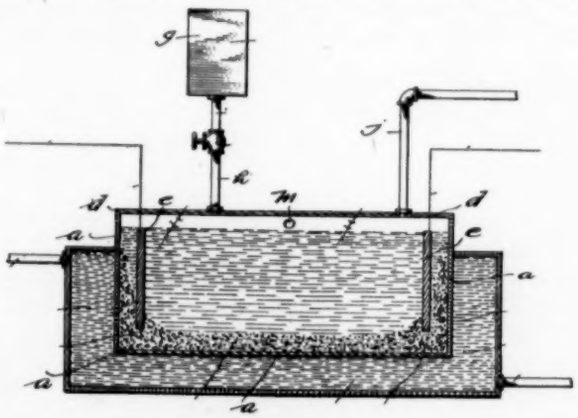


FIG. 1.—MANUFACTURE OF PEROXIDES.

the vessel. The vessel is first filled with fused sodium peroxide, and by means of cooling the walls with water a solidified peroxide lining is produced. By means of the electric current the peroxide held within the lining is kept in the fused state. Molten sodium is then permitted to flow through pipe *h* into the vessel *a*, while simultaneously air is admitted through pipe *j*. The molten sodium floating on top of the molten sodium peroxide is rapidly oxidized by the air and taken up by the molten peroxide, the excess of molten peroxide flowing out continuously through the outlet *m*. The heat generated by the oxidation of the sodium is, in the progress of the operation, practically alone sufficient to keep the sodium peroxide molten, so that little or no electric energy needs to be supplied to the cell afterwards.

Electrolytic Processes.

Electrodeposition of Copper.—Sherard O. Cowper-Coles, 873,508, Dec. 10, 1907. Application filed Nov. 12, 1906.

In electrodepositing copper from solutions which have to be maintained in an oxidized state (for instance, from a

cupric solution), the solution is brought continuously into intimate contact with air. For this purpose the electrolyte is conveyed through an atomizer consisting of revolving wheels or vanes, which throw the solution off them in the form of a fine spray against an outer casing. By subjecting the solution to strong light, such as daylight or arc light, it is claimed the effect of clarifying the solution is obtained.

Water Filter.—N. A. Brannon, 866,618, Sept. 24, 1907. Application filed April 11, 1906.

An electric water filter for household use in which the water passes through a filter and is at the same time subjected to the electric current produced by a short-circuited couple, the intention being to kill in this way the bacteria. The couple comprises zinc fragments and copper turnings. A porous filter partition of insulating material separates the two elements, which, however, are connected together by an electric conductor.

Batteries.

Storage Battery.—T. A. Edison, 879,612, Feb. 18, 1908. Application filed June 29, 1904. Assigned to Edison Storage Battery Co.

In the operation of the Edison alkaline battery excessive foaming has often taken place, which may, perhaps, have been due to the presence of microscopic scales in albuminous or gelatinous organic matter in the solution. This difficulty has been overcome by carefully filtering the alkaline solution through bone-black which has been first purified by washing in a hot caustic potash solution and then washing with water.

Storage Battery.—T. A. Edison, 876,445, Jan. 14, 1908. Application filed May 10, 1907.

In the development of the Edison alkaline storage battery the storage capacity of the nickel element has been found wanting. An effective remedy is to add about 2 per cent by weight of lithium hydroxide to the solution of alkaline hydrates. Preferable amounts of the latter are 15 per cent in the case of sodium hydrate and 21 per cent in the case of potassium hydrate. The addition of lithium hydroxide increases the capacity of the Edison battery by about 10 per cent, while the increase of the time over which the capacity may be maintained "is remarkable and of the highest commercial importance."

Primary Battery.—W. M. Brodie, 879,361, Feb. 18, 1908. Application filed Feb. 15, 1905. Assigned to Edison Manufacturing Co.

In order to increase the surface of the copper oxide plate in an Edison-Lalande cell the inventor produces corrugated copper-oxide plates without any binder by means of special dies. The dies are so formed that the tops or projecting portions of the corrugations of one die are opposite the depressions of the corrugations of the other die. Any abrupt curves are avoided and the corrugations are made well rounded. In this way it is possible to produce a deeply corrugated plate of sufficient strength.

Discharges Through Air.

Nitric Acid from Air.—H. Pauling, 877,447, Jan. 21, 1908. Application filed April 6, 1906. Assigned to Salpetersäure Ind. Ges.

After nitrogen oxide gases have been produced from air by means of electric discharges, water or steam is added to the hot gases so as to form an intimate mixture, while the nitrogenous gases have a minimum temperature of 200° C. The quantity of water or steam added is so proportioned that the vapors of nitric acid produced thereby have a temperature at which they are still in a gaseous condition; that is, a temperature of about 100° C. "The object in this case is to be able to pass the nitric acid while in its gaseous condition into metallic pipes, where it is cooled down to a certain temperature. It is then conducted into suitable clay apparatus for condensation. In these metallic cooling apparatus the gases of nitric acid are so far cooled down that the clay apparatus shall not be affected by an undue temperature of the gases received for condensation. Also the hot gases of reaction—that is, the nitrogenous gases resulting from the action of the electrical discharges on the air—may be received in metallic pipes, and here be mixed with the requisite quantity of water or aqueous vapor. It is advantageous, in connection with this process, to use such air as contains no more than ½ per cent of its volume as nitric oxide."

Nitric Acid from Air.—H. Pauling, 877,446, Jan. 21, 1908. Application filed Dec. 18, 1905. Assigned to Salpetersäure Ind. Ges.

After nitrogen oxides have been formed in air by means of electric discharges it is important to chill the gas mixture quickly. The inventor has formerly proposed the use of either tubes cooled by water or an atomizer. He now proposes to substitute plates, since they effect a more rapid cooling and also effectively avoid the formation of an aureola.

Nitric Acid from Air.—H. Pauling, 877,448, Jan. 21, 1908. Application filed June 30, 1906. Assigned to Salpetersäure Ind Ges.

To produce long arcs at high tension without danger of short circuits, the author proposes the arrangement shown in Fig. 2, where the upper diagram is a vertical section on the line 1-1 of the lower diagram, and the lower diagram is a horizontal section of the line 2-2 of the upper diagram. A current of air is blown through the pipe 1 between the electrodes 2, 2, which are arranged to diverge in lateral and upwards direction from pipe 1. The channel 4 receives another current of air, which enters in the direaction of the arrow I. The current of air passing along the channel 4 acts in its turn on the portion of the electrodes 2, 2 projecting into the channel 4, so as to blow between them and convey, in connection with the current of gas leaving the pipe 1, the discharges along the electrodes, so as to form arcs of the desired lengths with the avoidance of short circuits. The velocity of the current of gas in the channel 4 is less than that of the current arriving in the channel 3. These velocities must be ascertained by experiment.

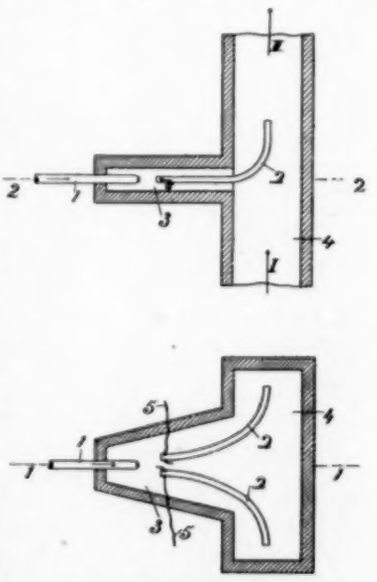


FIG. 2.—NITRIC ACID FROM AIR.

Cement Manufacture.—Seven powerful Corliss engines, designed for installation in a single industrial plant, with electric generator, motors, transformers and a full complement of auxiliary apparatus, including a separate condenser for each of the engines, constitute an order which is notable at any time and particularly so at present. This quantity of power machinery, now being built and installed by Allis-Chalmers Co. in cement mills at Nazareth, Pa., operated by the Atlantic Portland Cement Co., indicates something of the proportions which the cement-making industry is assuming. This industry appears to be indeed in a relatively healthy condition of trade, which contrasts strongly with the continued inactivity in some less favored industries.

Ferro-Vanadium for Foundry Purposes.

The use of vanadium for making special vanadium steels has attracted much attention during the last years. The chief properties of vanadium steel are as follows: The elastic limit is increased without an impairment of the ductility of the steel. That is, an exceedingly strong steel is obtained with its softness still remaining. Coupled with these most valuable properties is another, and that is the extreme resistance to deterioration when the metal is subjected to severe and continued strains in service. It is non-fatiguing, and therefore an ideal railroad and rolling-mill metal.

On the other hand, the use of vanadium for iron foundry purposes has received less attention. Dr. RICHARD MOLDENKE, the well-known secretary of the American Foundrymen's Association, has recently carried out some very interesting pioneer work in this field. He points out that the use of vanadium suggests itself for various purposes in the iron foundry. The very first casting which might be benefited is the car wheel. Next, the various kinds of rolls; then alkali pots, pump parts, etc.; anywhere, where strains are heavy and oft repeated, either direct tension and compression alternately, shock, or great variations in temperature.

In order to get some more definite idea of the effects of vanadium on cast iron, tests have been carried out at Dr. Moldenke's Castle in Watchung, N. J., using melted scrapped car wheels for white iron, and a good machinery pig iron for a variety of gray iron. A ferro-vanadium carrying high carbon was selected because it melted at a lower temperature and would also be cheaper for the foundryman. Varying proportions were added to the ladle full of molten metal, first in lump form; and as this did not give satisfaction with the small quantities of iron used at a time, the alloy was powdered before using.

Inasmuch as vanadium, besides being a great strengthener, is also a powerful deoxidizing agent, and the increase in strength obtained by its use might be attributed to the purification of the iron only, a further series of tests was included, in which the ladle was first treated with 80 per cent ferro-manganese in sufficient quantity to add 0.5 of manganese and then the ferro-vanadium. In order to obtain some light on the deoxidizing power of vanadium, a set of tests was also made with burnt metal.

The test bars were of the regulation kind, as prescribed by the American Society for Testing Materials, namely, 1¼-inch round, cast on end and in dried molds. The cupola was a small one, specially made for the tests, 22 inches inside the lining. The tuyeres were pretty close to the bottom, as but little iron was to be held at a time. A Sturtevant fan supplied the air, power being obtained from a small gasoline engine.

The test bars, dumped when cold, were only brushed and then broken transversely on a 5,000-pound Riehle testing machine. The test bars were carefully calipered, results of tests tabulated and the modulus of rupture calculated out in pounds per square inch.

Some tests were made with burned gray iron (burned grate bars, stove iron, etc.). The modulus of rupture of this iron was 25,500 per square inch. By adding 0.05 per cent vanadium this was raised to 43,380.

Some tests were then made with burned white iron. Without vanadium the modulus of rupture was 28,170 pounds per square inch. By adding 0.50 manganese and 0.05 vanadium, this was raised to 37,400.

An extended series of tests was made with machinery gray iron (melted pig iron, no scrap). Without vanadium the modulus of rupture was 38,680 pounds per square inch. By gradually adding small percentages of vanadium this could be raised to 53,750.

Even more remarkable results were obtained with remolded car wheels, white (no pig iron). Without vanadium the modulus of rupture was about 28,000 pounds per square inch. By gradual additions of vanadium and manganese this could be raised to 77,000. Some of the results of these tests are summed up in the following table, giving the chemical composition of the test pieces and the modulus of rupture in pounds per square inch:

Si.	*S.*	*P.*	*Mn.*	*V.*	*Lbs. Per Sq. In.*
.60	.122	.399	.38	none	27,760
.45	.096	.423	.40	.36	59,070
.66	.110	.591	1.15	.25	58,270
.45	.119	.414	.50	.31	56,130
.53	.084	.431	.74	.27	57,990
.42	.112	.417	.40	.45	59,316
.50	.081	.374	.54	.22	77,050

The ferro-vanadium used in these experiments contained 14.67 per cent carbon and 0.18 silicon. While the vanadium content is comparatively low, this is a very good alloy for foundry purposes, as cast iron is already high in carbon and the silicon is too small to cut any appreciable figure in the results.

Dr. Moldenke's conclusion is as follows: "The results are sufficient to strongly recommend the new alloy to the consideration of foundrymen. If but a part of the resistance to deterioration found by adding vanadium to steel should be proven by service trials to exist in cast iron, then, on the score of safety to human life alone, the metal belongs in every car wheel. A still better method would be to use a more powerful deoxidizer than manganese, and add the vanadium on top of it."

The investigations of vanadium in cast iron are intended to be continued, making provision to keep the ladle with melted iron heated up for a fairly long period, so that better mixing of the alloy may result, and hence more accurate results can be obtained. The full account of Dr. Moldenke's tests with all the figures may be found in the *Transactions* of the American Foundrymen's Association. This paper has now been reprinted as a pamphlet of the Vanadium Alloys Co., of New York City, who will be glad to send it to those interested. The Vanadium Alloys Co. are makers of the ferro-vanadium used in Dr. Moldenke's interesting experiments.

Metallurgical Activity at Guanajuato.

Probably no part of Mexico has been given more widespread publicity throughout the United States, within the past few years, than the Guanajuato mining district. The circumstance which has, in a relatively brief period, transformed this camp from a state of inactivity to that of the most active is the fact that through the advent of American capital and enterprise an hydro-electric plant, which transmits power over a distance of 120 miles from the nearest available water power, has been placed in operation here. The turbine installed has a capacity of 5,000 hp., and is a single horizontal unit of the Allis-Chalmers scroll case type, operated by the Guanajuato Power & Electric Co., at Guanajuato.

There were millions of tons of ore in the dumps of the old mines, and underground vast reserves practically developed or used as filling. The dumps were sampled, extensive cyanide tests made, and with cheap power available, these properties have become very valuable.

One of the representative mills of the district is that owned by the Porogrina Mining & Milling Co. In this mill practically the entire equipment was furnished by Allis-Chalmers Co., of Milwaukee. The ore goes to Gates style "K" gyratory breakers, and discharges onto a belt conveyor for distribution to the bins back of the stamp batteries. The present plant, with 120 stamps, handles about 9,000 tons monthly, which amount it is expected will shortly be increased to 11,000 tons, following certain proposed changes in the treatment of ores. Ore was originally crushed to 40-mesh, in batteries not set in cyanide

solution. The product of each five stamps went to a Wilfley table for concentration, while the tailings passed to two 6-foot cones, used as pulp thickeners. From the thickeners the sands were conveyed to Gates tube mills, 5 feet x 26 feet, each driven by a 75-hp. induction motor. Iron plates are used here for tube mill linings in place of silex.

The sands from the cone separators were run to one of two sand collecting tanks, with Butters distributors and center discharge gates, arranged with curtains to take off slimy water, which was returned to the cones. From the collectors the sands went into a sand leaching excavator. The overflow from the cone plant passed to two 36 feet x 12 feet steel tanks, arranged with overflow launders used as slime collectors. The underflow, which is a thick slime, was delivered to a slime agitation plant, using combined mechanical stirring and air agitation.

It is now proposed to increase the output by the following changes in treatment: To crush in solution and take out plates; to put classifiers ahead of concentration, and to crush only to 30-mesh, thus increasing tonnage. It is estimated that the pulp when it reaches the cyanide plant will have 35 per cent to 40 per cent of the values in solution, which will be decanted and precipitated and enable the cyanide plant to handle a larger quantity than has been practicable heretofore.

The New 6000-Ton Garfield Concentrator of the Utah Copper Co.

At the present time there stands blocked out in the mines belonging to the Utah Copper Co. more than 100,000,000 tons of ore, the milling of which will probably be done at the new Garfield concentrator plant just brought to completion. This is estimated to have cost $3,000,000, including a $750,000 power plant.

The concentrator buildings are located 16 miles east from Salt Lake City, on a slope facing the lake. The plant is fed by means of the Bingham branch of the Rio Grande Western Railroad from the company's mines in Bingham Canon. It is designed to treat 6,000 tons of porphyry daily, with a copper content varying from 1.5 to 2.5. The resulting concentrates carry more than 150,000 pounds of copper.

Ore is received in a bin building with a holding capacity of 36,000 tons, or six days' supply. The concentrator proper is divided into twelve separate groups, each a complete unit in itself and having a capacity of 500 tons, the machinery of which is driven by means of induction motors.

Coarse Crushing Department.

Ore is taken from the bins in collecting cars, then discharged through centrally-placed bottom-gates directly onto the grizzlies over the hoppers of four 7½' type-"K" Gates gyratory breakers, built by the Allis-Chalmers Co., Milwaukee, each having a capacity of 100 tons per hour. These crushers are fed from the hoppers through discharge pockets with vertical gates operated by compressed air. Only the oversize from the grizzlies goes to the crushers; the undersize passes along to the first set of trommels, of which there are two for each of the Gates crushers.

Elevated to the mill top, the dry, coarse crushed ore is screened wet through No. 10-mesh screen. Pulp passing the screen is classified and then sent to the jigs. The concentrator floors are occupied by 72 jigs, 1,104 6-foot vanners and 48 concentrating tables. Each of the twelve mill sections may be operated entirely independently from the others.

The power for operating the coarse crushing machinery is supplied from four 150-hp., 3-phase induction motors, 440 volts. Each motor is belted to a line shaft, which drives a gyratory crusher, a set of roughing rolls, two trommels and elevators.

Power Plant Equipment.

A power station having nearly 7,000-hp. capacity is required for the operation of the main mill and a small 700-ton mill at Bingham Canon, originally built as an experimental plant. The power house, built of reinforced concrete brick and steel, 158 feet x 228 feet, stands a short distance below the mill. Twenty water-tube boilers of the Heine type, built by the Risdon Iron Works, of San Francisco, furnish a boiler capacity of 600 hp. each for reciprocating engines, direct connected to 3-phase alternating-current generators. Two of the engines installed were built by Allis-Chalmers Co., Milwaukee. They are horizontal cross-compound Reynolds-Corliss units, of the heavy duty type, with cylinders 54-inch x 48-inch stroke, and designed to develop normally 1,500 hp. each at 100 r. p. m.

Messrs. J. G. White & Co. acted as consulting engineers for the plant. Power is generated at 4,000 volts, which is stepped down to 440 volts for use in the mill. Power for Bingham Canon mines and mill is transmitted over a 15-mile line at 40,000 volts.

The Ammonia-Cyanide Process for Treating Copper Ores with Recovery of Precious Metals.

The Mosher-Ludlow ammonia-cyanide process, which is now being introduced into practice by the Ammonia Cyanide Engineering Co., 347 Monadnock Block, San Francisco, is an interesting new development in the leaching and treatment of ores carrying copper with or without gold or silver values. In mechanical equipment as well as general arrangement of plant the process is similar to the cyanide and chlorination leaching processes, in so far as the solution of the metal values is concerned. But it differs radically from the latter two processes in the precipitation of the metallic values from the solution, since the essential feature of the new process is the recovery of the metal from the ammonia solution through boiling the latter in the Mosher-Ludlow continuous boiling-out apparatus, to which we referred already in our June issue, 1907 (Vol. V., p. 242).

The use of ammonia and potassium cyanide for the extraction of copper, gold and silver from ore is not a new idea. The fundamental patent is probably that of Simpson (United States patent 323,222, issued July 28, 1885), who first suggested the use of ammonia and potassium cyanide for such purposes.

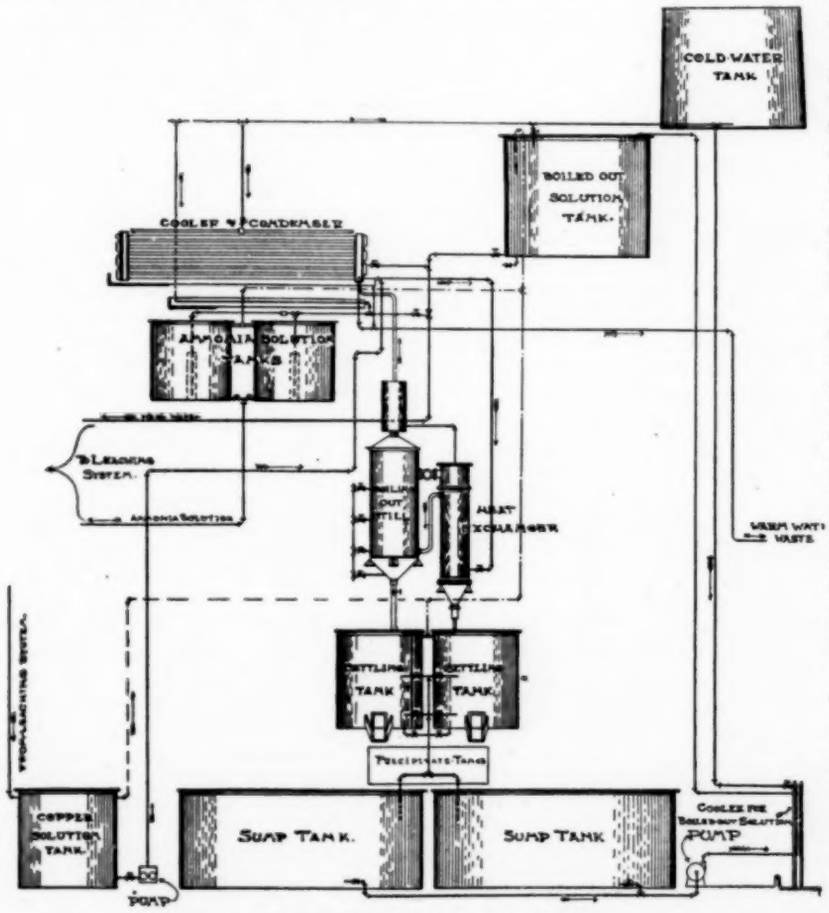
The distinguished German metallurgist Dr. Schnabel and associates, already, thirty years ago ,1878), installed ammonia leaching plants for the extraction of zinc oxide from zinc-lead dross, waste from desulphurizing works, with subsequent boiling-out of the zinc as oxide. Such plants at Lautenthal and at Hoboken, near Antwerp, are believed to have been operating with brilliant success for a number of years. For detailed description of this process the reader may be referred to Schnabel's *Metallurgy*, Vol. I., second (English) edition, pp. 679 to 687.

To use Schnabel's own words, "the process depends upon the easy solubility of zinc oxide in ammonium carbonate solution, and upon the fact that from this solution ammonia and a part of the carbon dioxide may be recovered by boiling, while zinc carbonate is precipitated and may be converted into the oxide by ignition. The solvent power of the ammoniacal solution is restored to it by passing into it the carbon dioxide given off upon heating the basic zinc carbonate." Schnabel's own criticism of the process is that it is "complicated, requiring costly plant and expert attendance, and that the zinc is obtained in a form in which it sells for less than metallic zinc, though there is the advantage that the silver yield is high."

From Schnabel's own description of the details of the process it is quite certain that the weak point was mainly in the ammonia distilling plant. His way of boiling off the ammonia and precipitating the zinc carbonate would probably never do

in the treatment of ores under large-scale milling conditions, where immense tonnages are to be handled, and where the apparatus must not be too expensive or cumbersome either in first cost or subsequent operation. It would seem that just at this point the Mosher-Ludlow process, with continuous operation as fundamental principle, as described below, is specially strong.

With respect to the use of ammonia, an immense number of patents have been taken out in the past few years in this country and abroad, but very little has been done from a practical standpoint to the present time in the use of ammonia for treating ores. It is, therefore, of special interest to know that the Mosher-Ludlow process is to be used on a 30-ton ammonia



CONTINUOUS BOILING-OUT APPARATUS.

leaching plant to operate on a copper-bearing sandstone near Hite, Utah, which is now being constructed. It is expected that the plant will start operation in the spring.

The Mosher-Ludlow process depends on the principle that ammonia, NH_3, at the ordinary temperature forms soluble, stable compounds with the oxides, hydroxides or carbonates of copper, zinc, nickel or cobalt, such as $Cu(NH_3)_2$.

These ammonia metal compounds are readily dissolved by water containing a small excess of ammonia over that required to form the soluble compound. This is the leaching step of the process.

The precipitation step of the process depends on the fact that those soluble ammonia-metal compounds break up with great ease at the boiling point of water into the oxide or hydrate of the metal, which almost instantly settles as a heavy precipitate, while the ammonia, originally combined, is set free, to be reabsorbed in cold water or boiled-out solution for use over and over again. While the process will be described here in its application to copper ore, it is equally applicable to zinc, nickel and cobalt.

Where the percentage of copper is large the aim is to first extract as much of the copper as is possible by plain ammonia, and to leave the gold and silver values to be subsequently extracted with a weaker ammonia solution containing fractional percentages of potassium cyanide. But instead of working in this way it may be preferable in many instances to add the cyanide at once to the ammonia and to simultaneously extract all of the values, including copper, gold and silver, with an ammoniacal solution containing one to several pounds cyanide per ton. The object aimed at is to reduce the consumption of cyanide to a minimum in the presence of copper, by substituting ammonia as the solvent for the copper, thereby permitting the minute amounts of potassium cyanide added to the ammonia solution to simultaneously extract the gold and silver values.

To recover the metallic values from the ammonia-cyanide-copper-gold-and-silver-bearing solution, it is passed through the continuous boiling-out still, to precipitate the copper as CuO. The boiled-out solution holding the gold and silver values is agitated with the least amount of zinc dust, or passed through zinc boxes to recover such gold and silver as the boiled-out solution may contain.

Before we pass over to the description of the boiling-out apparatus a few remarks may be made concerning the nature of the ores which can be treated by this process. It is claimed that the complex mineral character of an ore is of no importance to the success of the process, since the ammonia will readily extract the ammonia-soluble metals from gangue with a composition of minerals, which would render acid leaching entirely out of question. Ores with a limestone gangue which, on leaching with dilute acids, form gelatinous silica or pack cement and form an impervious filter bed, may be treated with extreme ease by the use of ammonia.

For leaching a coarsely ground ore (16-30 mesh) containing appreciable percentages of the ammonia-soluble metal, the chlorination barrel, as designed by the Ammonia Cyanide Engineering Co., *nonlead lined,* with arched internal filter, is strongly recommended. It forms an absolutely ammonia-tight receptacle, easily charged and discharged, and in which agitation and washing-out of the ammonia from the final tailings can be attained in a very thorough manner. Flights or baffles may be arranged on the inner periphery, thereby greatly aiding the agitation, with consequent rapid solution of the ammonia-soluble metal oxide. The company have also designed a special quartz filter for the purpose.

As to the treatment of slimes, that may be varied, dependent on the oxidized or sulphide condition of the material. In the one instance, simple agitation, in closed tanks arranged vertically with conical bottoms, plus subsequent primary decantation, to remove the greatest possible portion of the ammonia-metal solution, followed by adding wash water to dilute sludge to filtering density, which is then finally forced through a closed type filter apparatus of the Kelly, Burt, Sweetland, or other type of press, and the sludge well washed to free it from NH_3. A large number of these filter machines are now being offered to the cyaniding profession, as is well known.

Sulphide copper slimes need a preliminary oxidation, or methods which latently render the copper mineral soluble in

an ammonia solution. There is still room here for a great deal of work.

Due to the very powerful oxidizing action of a solution of cupric oxide (CuO) in ammonia, unoxidized silver minerals may be attacked and finally dissolved in the *raw* state, obtaining in this manner a percentage of extraction out of this character of mill product entirely impossible by ordinary cyanide methods.

With the standard roasting methods it is claimed that practically every known copper, zinc or nickel ore may be adapted to ammonia-cyanide methods of ore treatment; ammonia yielding a very high percentage from the properly roasted ore and a high-grade product of extreme purity.

It is, of course, of the greatest importance to have a thoroughly ammonia-tight equipment so as to hold the loss of ammonia down to the lowest possible limit. This is even of greater importance in the second half of the process, which comprises the boiling out of the ammonia solution. As mentioned before, the copper oxide is hereby precipitated. This commands an independent market of its own. Since the ammonia solution of copper is practically free from lead, antimony, iron and all injurious elements, it precipitates a copper oxide which is almost chemically pure.

As mentioned above in connection with the Schnabel process, Mr. D. Mosher recognized at an early state that the solution of the various mechanical difficulties involved in boiling out the solution and precipitating the copper oxide would be of first importance, and that it demanded highest engineering skill of an ammonia engineering specialist. He therefore approached some years ago Mr. James D. Ludlow, an expert refrigeration and mechanical engineer and chief designer for the Vulcan Iron Works of San Francisco. Mr. Ludlow first suggested the *continuous* boiling-out process, which Messrs. Mosher & Ludlow then worked out.

It may be compared in some way to the artificial ice and cold-storage industry in which ammonia water is boiled in a still, the ammonia gas distilled off, liquefied under pressure by powerful pumps, then permitted to expand, by which the cooling effect is produced, and finally reabsorbed in cold water to commence the same cycle of action over and over again. A slight mechanical loss of ammonia has to be continuously replaced, amounting to a small operating expense. In the ammonia-cyanide process no pressure is used and only dilute ammonia solution.

The general scheme of the Mosher-Ludlow continuous boiling-out apparatus is shown in the adjoining diagram. The chief feature is that the greatest care has been taken in its design to prevent the loss of ammonia and to reduce the quantity of heat consumed in boiling to a minimum. This is accomplished by a perfect system of heat interchange; the incoming cold ammonia-copper solution is brought in contact with the heat of the ammonia-steam vapor in the cooler and condenser and in the heat exchanger on its way to the boiling-out still, with the overflowing boiled-out solution. It will thus be seen that an important part of the heat applied to boil out the ammonia is passed to the incoming solution, thus saving steam and fuel.

The ammonia solution is at all times handled in closed vessels, and the same water is used over and over, so that if any copper or ammonia remains in solution after boiling there is no loss. The continuous feature of the apparatus allows of the use of comparatively small vessels, and permits of the heat exchange to the best advantage. The course of the solution through the apparatus will be easily seen from the diagram in connection with the following description.

The ammonia-copper solution is taken from the copper-solution tank and pumped through inner coil of the double-pipe counter-current cooler; thence it passes to the heat exchanger, thence to the boiling-out still, thence into exchanger, where part of its heat is passed to the incoming solution; thence to the settling tanks, where the precipitate (almost pure copper oxide) is allowed to settle, the liquid being drawn off into the sump tanks. From the sump tanks the boiled-out solution is pumped through a cooler up to the boiled-out solution tank. From there it is used as needed to make fresh ammonia solution, and as wash water.

The ammonia and steam vapor from the boiling-out still passes up to the cooler and condenser into the annular spaces between the two pipes, parting with a fraction of its heat to the ammonia-copper solution in the inner pipe. From the cooler and condenser the ammonia water flows into the ammonia solution tanks, where it is diluted and is ready to be sent to the leaching system. A supply of cold water is kept flowing over the outside of the cooler and condenser and the boiled-out solution cooler. The precipitate is removed from the settling tanks from time to time, depending on the accumulation.

The first cost of the continuous boiling-out apparatus complete, including all steel tankage, piping, pumps, etc., is stated to be about $6,000 for a plant of 100 tons capacity. As to the fuel required in boiling out a solution containing ammonia and copper, the following figures are given by the company.

The fuel required in boiling out 2 per cent ammonia-copper solution on a 100-ton (24-hour basis), and precipitating the copper as black oxide = 79.8 per cent Cu., may be found as follows:

One hundred tons solution are equivalent to 25,000 gallons water, of which, at the utmost, 10 per cent has to be evaporated during boiling to drive out most of the ammonia. Besides the 10 per cent evaporation (2,500 gallons) water, 2 per cent. NH_3, equivalent to 5,000 pounds anhydrous ammonia, will also demand a certain amount of heat to drive it over. Further, the whole 25,000 gallons solution have to be heated from 70° F. to 212° F. The total heat required for these purposes is 51,083,000 B. T. U., of which, however, according to experience, 60 per cent are saved by the heat exchanger, so that the net heat required amounts to 34,333,000 B. T. U.

In practice this required heat can be obtained from 1½ to 2 tons of a good coal, and with a boiler of from 35 to 40 hp.

In view of the complete success of ammonia, cold-storage plants in beef-packing plants, breweries, etc., it would appear that the ammonia cyanide process, as sketched above, should not involve exaggerately great difficulties if only the apparatus is properly designed and installed. On the other hand, the process apparently solves some important metallurgical problems, like the treatment of such copper, gold ores and tailings as have heretofore yielded no profitable returns by other systems of treatment. Oxide and carbonate ores yield very readily to the process.

Similar, as in cyaniding, the process may be applied after the stamp mill and concentrating table have done their work, and have still left sufficient values to be profitably treated by a subsequent leaching.

Classification of sands and slimes, as well as of sliming methods, may be adopted, depending on whichever gives the more economical system of treatment.

Through the very energetic oxidizing action of a copper oxide-ammonia solution, sulphide silver ores, with ruby silver, stephanite, argentite, etc., will give a more thorough extraction by ammonia-cyanide methods than is possible by plain cyaniding. In many instances where chloridizing-roasting and "hypo" leaching is applied it is claimed that extraction by this process will be just as effective on the raw ore and thereby avoid the cost of roasting.

It will certainly be of interest to await the results to be obtained at the first plant which, as noticed before, is soon to be opened in Utah.

The Kny-Scheerer Co. were among the many concerns which suffered heavy losses during the recent fire of the Parker Building. Fortunately, a few months before, the laboratory supplies department had been moved to the factory of the company at Ninth Avenue and Twenty-Seventh Street, New York, where the main offices are now also located.

Notes.

Messrs. Geo. D. Feidt & Co. (successors to Bullock & Crenshaw), manufacturers and dealers in chemical apparatus and chemical supplies, at present located at 528 Arch street, Philadelphia, will move on or about May 1 to new quarters, at 29-31 North Seventh Street.

Centrifugals, Extractors and Separators.—The D'Olier Engineering Co., of Philadelphia, have sent us their illustrated pamphlets on centrifugal and turbine pumps and on electric-motor-driven centrifugals, extractors and separators for syrup, water, liquor and oil extraction, etc.

Fixation of Atmospheric Nitrogen.—The Tesla Nitrates Co. has been organized at Portland, Me., for the purpose of producing nitrogen compounds by an electric process of Nicola Tesla from atmospheric air. The company is capitalized at $500,000, and the officers are James E. Mantor, Portland, president, and Clarence E. Eaton, Portland, treasurer.

Book of Chemical Labels.—We have received from the Kny-Scheerer Co., of New York City, a copy of their new label book, which has been prepared by Dr. Herbert Raymond Moody. The advantage of using uniform labels in laboratories is evident. Although an absolutely universal set cannot well be printed, this collection, which provides printed labels for all ordinary reagents and the more common chemicals used for general purposes in well equipped laboratories, will undoubtedly meet a demand. The book contains some 450 printed labels besides a number of blank labels. The price of the book is 35 cents for single copies and 25 cents each if ordered in larger quantities.

Blowers and Exhausters.—The J. B. & J. M. Cornell Co., of New York City, have just issued an illustrated pamphlet on their pressure blowers and exhausters. The claims of the manufacturers are that greater volume and higher pressure are produced with less horsepower than by any other type. The blowers are designed specially for use in connection with cupola furnaces and forges, and for producing mechanical draft for steam boilers, sand blasts, pneumatic tube delivery, or for any purpose where high pressure combined with large volume is desired. The pamphlet gives a concise, illustrated description of the chief features of construction of Cornell blowers and exhausters and tables of dimensions.

Water-Jet Primers.—While steam-jet primers are extensively used for priming syphon pipes, centrifugal pumps, long suction pipes of piston pumps and air vessels, there are cases in which they cannot be used on account of steam not being available; for instance, where the pumping station is driven by gas engines or located too far from the boiler plant. As water is always available in a pumping station, water jets are useful in such cases. The Schutte & Koerting Co., whose steam-jet primers and water-jet primers are widely in use, describe in a recent illustrated pamphlet the construction, installation and operation of water-jet primers. This company also make automatically working water-jet primers. The jet apparatus is installed inside of the vessel, and the pressure water is started automatically by a float when the water level decreases, evacuating until the water has risen to the proper height, when the water supply is automatically shut off by means of a float-actuated water pressure valve.

Messrs. E. H. Sargent & Co., of Chicago, have recently issued a supplementary price list of their chemical apparatus and assayers' supplies. This is a supplement to their general chemical catalog of 1905, covering a great number of new or improved apparatus and designs which have come out since that time. Among them are Sargent's distilling apparatus, Camp's shaking machine, Morehead's gas apparatus, electric hot plates, electric ovens, electric furnaces, electric thermostats and pyrometers. The catalog is arranged alphabetically and well illustrated.

Thermit for Repair Work.—A neat pamphlet recently issued by the Goldschmidt Thermit Co., of New York City, gives shop instructions for the use of thermit in repair work. The instructions are given in a very concise yet complete manner, so as to be easily understood. Among the different applications for which special instructions are given are the repairs of locomotive drivers, repairs of connecting rods, repairs of electric motor cases (a new and very interesting application of thermit), repairs of flaws in castings and repairs on larger sections. A number of instructive diagrams and illustrations is given.

Pyrometers.—Catalog No. 20, recently issued by William H. Bristol, 45 Vesey Street, New York City, deals with electric pyrometers for blast furnaces (indicating, recording and combination outfits) for temperatures of hot blast and top gas. The indicating instrument is for the use of the attendant at the furnace, the recording instrument for use of the superintendent in his office, while a portable instrument is provided for general tests. The different types of pyrometers are concisely described. The catalog is profusely illustrated.

Wood Pipe.—In a recent circular of the A. Wyckoff & Son Co. the following advantages are claimed for their wood pipe, which is made by special method, with careful selection of the finest white pine. The wood pipe is cheaper than metal pipe. Owing to its lighter weight it costs less to transport and lay. It can be laid nearer surface, thereby saving the expense of a deep trench, and unskilled labor can handle it. It is not injured by acids, fumes, sulphur or other poisonous impurities. It does not rust. Salt water does not affect it and vegetable matter does not clog it. It is more durable than either wrought iron or steel, and under proper conditions it is as durable as cast iron. It is made to stand all pressures up to 160 pounds.

Spiral Riveted Pipe.—The American Spiral Pipe Works, of Chicago, Ill., have recently issued a fully illustrated pamphlet on the various uses, advantages and economies of Taylor's spiral-riveted pipe, forged steel pipe flanges, etc. The spiral-riveted pipe is intended especially for pressure purposes. When such pipe is tested to the bursting point, the rupture always occurs in the solid metal, demonstrating the spiral riveted seam to be the strongest part of the pipe. In addition to its enormous bursting strength, spiral-riveted pipe has exceptional strength for resistance of collapsing under vacuum or heavy earth fills. This pipe is also extensively employed for hydraulic mining and sluicing work in connection with giants or nozzles. For exhaust steam purposes the galvanized flanged pipe is in extensive use.

The Taylor Instrument Companies, a new corporation, of Rochester, N. Y., is the outgrowth of the thermometer business established in 1851 by George Taylor. In the middle of the sixties the firm became Taylor & Richardson, in the early seventies Taylor Bros., and in 1890 the firm was incorporated as Taylor Bros. Co. Since then the company has acquired the business of the Hohmann & Maurer Manufacturing Co., makers of high-grade thermometers and gauges for industrial purposes; the Watertown Thermometer Co., makers of general thermometers and thermometers for advertising purposes; the R. Hoehn Co., makers of commercial thermometers and hydrometers; Short & Mason, Ltd., of London, England, makers of barometers, compasses, meteorological and surveying instruments; the H. & M. Automatic Regulator Co., owners of valuable patents on temperature and pressure regulation and control for domestic and industrial purposes, and recently the American branch of the renowned Cambridge Scientific Instrument Co., of Cambridge, England, whose pyrometers and measuring instruments in general have a world-wide reputation. One of the latest achievements of the latter company is, as our readers know, a radiation pyrometer, which may be used as indicating as well as recording instruments.

Tungsten.—Messrs. Geo. G. Blackwell, Sons & Co., Ltd., of Liverpool, have erected at Garston, a suburb of Liverpool, a new works for the manufacture of alloys and metals, and particularly tungsten metal, for the steel trade. It is stated to be 96 to 98 per cent pure and practically free from carbon. The tungsten ore comes from Portugal and Australia. They also make ferro-tungsten, containing 80 to 86 per cent tungsten with ½ to 1 per cent carbon and other lower grades.

Mr. John Fritz, of Bethlehem, Pa., the well-known metallurgical engineer and veteran iron master, has been elected a member of the board of trustees of Lehigh University, and has accepted the position. His universally recognized high standing among the engineers of the country makes this addition to the board of trustees of this technical institution eminently fitting.

Digest of U. S. Patents.

Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.

CALCIUM CARBIDE (*Continued.*)

651,167, June 5, 1900, James E. Hewes, Baltimore, Md. Assignor to the Provident Life & Trust Co., trustee, of Philadelphia, Pa.

Calcium carbide is produced by smelting a mixture of coke and lime in a rectangular furnace having a hinged rear wall, in the lower portion of which is set a carbon block which is not connected in circuit. Two horizontal parallel electrodes of opposite polarity rest upon the bottom of the furnace, means being provided for retracting them longitudinally. To initiate the reaction the two electrodes are brought into contact with the carbon block, thereby closing the circuit; they are then retracted to form two arcs in series between the respective electrodes and the block. As the carbide is produced the electrodes are retracted until a block or mass of carbide is produced; the hinged rear wall is then dropped and the carbide extracted from beneath the unconverted charge.

651,916, June 19, 1900, John Zimmerman and Isedore S. Prenner, of Chicago, Ill.

The furnace comprises a rectangular chamber having a tilting hearth disposed above the bottom. Opposed electrodes, in arcing relation, enter the furnace above the hearth through opposite side walls. A casing carrying a hopper and containing a compressing screw projects into the furnace opposite the gap between the electrodes, the arrangement being such that a mixture of lime and carbon fed to the casing may be gradually passed into the arc. The mixture is preferably in the form of a stiff paste, with or without a binder, such as borax, graphite and iron, or molasses, but it is stated that the process may be successfully operated without the use of a binder. In order to support the mixture between the aperture of the casing and the arc an apparatus is provided for feeding beneath the mixture and forwardly to the arc stiff paper or cardboard, the construction being such that the rate of movement of the cardboard support is the same as that of the charge to be smelted. It is alleged that the process is continuous and economical with respect to the loss of heat. The carbide is discharged into the bottom of the furnace at intervals by tilting the hearth.

652,877, July 3, 1900, Richard Charles Baker, London, England.

By the reduction of calcium borate by means of carbon in presence of iron, nickel, chromium, tungsten or compounds of these metals, calcium carbide is produced simultaneously with ferro-boron, nickel-boron, chromium-boron, or tungsten-boron. The specification refers to the use of the above-mentioned boron alloys for alloying with steel.

NEW BOOKS

A TREATISE ON CHEMISTRY.—By Sir H. E. Roscoe and C. Schorlemmer. Two vols. Vol. II., the metals. New edition completely revised by Sir E. Roscoe and Dr. A. Harden. 1,448 pages; illustrated. Bound in cloth. Price, $7.50 net. New York: The Macmillan Co.

STOICHIOMETRY.—By Sydney Young; together with an introduction to the study of physical chemistry by Sir W. Ramsay. (Describing the laws of chemical combination, then gives a detailed account of the properties of gases, and then proceeds to a discussion of the methods of determining atomic weights.) 442 pages; 88 illustrations. Bound in cloth. Price, $2. New York: Longmans, Green & Co.

INORGANIC CHEMISTRY.—By E. I. Lewis. 424 pages. Bound in cloth. Price, $1.25 net. New York: G. P. Putnam's Sons.

TECHNICAL METHODS OF ORE ANALYSIS.—By Albert H. Low. Third edition, revised and enlarged. 356 pages. Bound in cloth. Price, $3. New York: John Wiley & Sons.

LABORATORIUMSBUCH FÜR DEN METALLHÜTTENCHEMIKER.—By H. Nissenson and W. Pohl. Vol. II.; 86 pages. Paper cover. Price, Marks 3. (Retail price in New York, $1.) Halle a. S.: Wilhelm Knapp.

THE UTILIZATION OF WOOD WASTE BY DISTILLATION.—By Walter B. Harper. A general consideration of the industry of wood distilling, including a description of the apparatus used and the principles involved, also methods of chemical control and disposal of the products. 160 pages; illustrated by 74 engravings. Bound in cloth. Price, $3. St. Louis, Mo.: *St. Louis Lumberman.*

MODERN PIGMENTS AND THEIR VEHICLES.—By F. Maire, Their properties and uses, considered mainly from the practical side, and how to make tints from them. 275 pages. Bound in cloth. Price, $2. New York: John Wiley & Sons.

FERTILIZERS.—By E. Burnett Voorhees. The source, character and composition of natural, home-made and manufactured fertilizers, and suggestions as to their use for different crops and conditions. Tenth edition. 349 pages. Bound in cloth. Price, $1.25 net. New York: Macmillan Co.

TEXT-BOOK ON PAPER MAKING.—By C. F. Cross and E. J. Bevan. Third edition, partly rewritten with new matter. Bound in cloth. Price, $5. New York: Spon & Chamberlain.

THE MINER'S GEOLOGY AND PROSPECTOR'S GUIDE FOR MINING STUDENTS, MINERS, PROSPECTORS AND EXPLORERS.—By G. A. Corder. 237 pages; illustrated. Bound in cloth. Price, $2. New York: Spon & Chamberlain.

MINING TABLES.—By F. H. Hatch and E. J. Vallentine. Being a comparison of the units of weight, measure, currency, mining area, etc., of different countries, together with tables, constants and other data useful to mining engineers and surveyors. 208 pages. Bound in cloth. Price, $1.90 net. New York: The Macmillan Co.

A TEXT-BOOK OF PHYSIOLOGICAL CHEMISTRY.—By Olof Hammarsten. Authorized translation from the author's enlarged and revised 6th German edition by J. A. Mandel. 853 pages. Bound in cloth. Price, $4. New York: John Wiley & Sons.

THE SPECTROSCOPE.—By T. Thorne Baker. Its uses in general analytical chemistry; an intermediate text-book for practical chemists. Well illustrated. Bound in cloth. Price, $1.75 net. New York: William Wood & Co.

A SCHEME FOR THE DETECTION OF THE MORE COMMON CLASSES OF CARBON COMPOUNDS.— By Frank E. Weston. New edition, having been somewhat revised. 103 pages. Price, 90 cents. New York: Longmans, Green & Co.

LES DECOUVERTES MODERNES EN PHYSIQUE.—By O. Manville. 186 pages; 32 illustrations. Paper cover. Price, 5 francs (retail price in New York, $1.35). Paris: Librairie Scientifique, A. Hermann.

A LABORATORY GUIDE FOR STUDENTS IN PHYSICAL SCIENCES.—By H. Schapper. 66 pages, bound in cloth. Price, $1. New York: John Wiley & Sons.

THE GAS ENGINE IN PRINCIPLE AND PRACTICE.—By Arthur H. Goldingham. 195 pages; illustrated. Bound in cloth. Price, $1.50 net. New York: Spon & Chamberlain.

POWER AND POWER TRANSMISSION.—By Eugene W. Kerr. A work designed for elementary instruction in colleges and manual-training schools. Second edition revised. 380 pages; illustrated. Bound in cloth. Price, $2 net. New York: John Wiley & Sons.

HANDBOOK OF STEAM AND ELECTRICAL ENGINEERING.—By H. C. Tulley. 1,000 pages; illustrated. Price, $3.50. New York: Hill Publishing Co.

AN INTRODUCTION TO THE STUDY OF ELECTRICAL ENGINEERING.—By H. H. Norris. 409 pages; illustrated. Price, $2.50. New York: John Wiley & Sons.

MODERN VIEWS OF ELECTRICITY.—By Sir Oliver Lodge. 532 pages; illustrated. Price, $1.25 net. New York: Macmillan Co.

THEORETICAL MECHANICS.—By A. E. H. Love. An introductory treatise on the principles of dynamics, with applications and numerous examples. Second edition. 383 pages; illustrated by diagrams. Bound in cloth. Price, $3.00. New York: G. P. Putnam's Sons.

A HAND BOOK OF GENERAL INSTRUCTION FOR MECHANICS.—By Franklin E. Smith. Containing useful rules and memoranda for practical men. 335 pages; illustrated. Bound in cloth. Price, $1.50 net. New York: D. Van Nostrand Co.

TECHNICAL THERMODYNAMICS.—By G. A. Zeuner. Translated from the fifth complete and revised edition of "Grundzüge der mechanischen wärmetheorie," Jos. Frederic Klein. Contents: Vol. 1, Fundamental Laws of Thermodynamics, Theory of Gases; Vol. 2, The Theory of Vapors. Vol. 1, 460 pages; Vol. 2, 556 pages; illustrated. Price, $8.00 net. New York: D. Van Nostrand Co.

SUPERHEAT, SUPERHEATING AND THEIR CONTROL.—By W. H. Booth. 170 pages; illustrated by tables and diagrams. Price, $1.50 net. New York: D. Van Nostrand Co.

THE GAS ENGINE.—By F. R. Hutton. Third edition revised. Bound in cloth. Price, $5.00. New York: John Wiley & Sons.

TABLES OF THE PROPERTIES OF STEAM AND OTHER VAPORS AND TEMPERATURE-ENTROPY TABLE.—By Cecil H. Peabody. Seventh edition, rewritten. 136 pages. Price, $1.00. New York: John Wiley & Sons.

STEAM TURBINES.—By Carl C. Thomas. Third edition revised and enlarged. 347 pages; illustrated. Price, $4.00. New York: John Wiley & Sons.

STEAM TURBINES.—By Lester G. French. 340 pages; illustrated. Bound in cloth. Price, $3.00. New York: Hill Publishing Co.

PEAT, ITS USE AND MANUFACTURE.—By P. R. Björling and F. T. Gissing; illustrated. Price, $2.00 net. Philadelphia: J. B. Lippincott & Co.

REINFORCED CONCRETE.—By Walter L. Webb. A treatise on cement, concrete and concrete steel and their applications to modern structural work. 129 pages; illustrated by plates and diagrams. Price, $1.00. Chicago: American School of Correspondence.

SCIENCE AND HYPOTHESIS.—By Jules Henri Poincaré, with a preface by Jos. Larmor. The author gives a Socratic exposition of the limitations of the human outlook on the universe, but he does not count these limitations as imperfections, and he leaves the reader with a wide conception of the wonderful fabric of human knowledge. He shows that all thinkers and experimenters need hypotheses from which to start to study out different theories of the world as a whole. The mathematics of the book require a trained reader. 271 pages. Price, $1.25 net. New York: Charles Scribner's Sons.

PRACTICAL INTEGRATION.—For the use of engineers, etc. By A. S. Percival. 86 pages. Price, 80 cents net. New York: The Macmillan Co.

EVERY-DAY LAW; OR THE LAW OF CONTRACTS.—By Rob. C. Strong and C. B. Denson. 355 pages. Price, $2.50. Raleigh, N. C.: Edwards & Broughton.

A HISTORY OF POLITICAL ECONOMY.—Second edition. By J. K. Ingram. 263 pages; illustrated. Price, $1.50 net. New York: The Macmillan Co.

ESSENTIALS OF ECONOMIC THEORY AS APPLIED TO MODERN PROBLEMS OF INDUSTRY AND PUBLIC POLICY.—By J. Bates Clark. 580 pages; illustrated by diagrams. Price, $2.00 net. New York: Macmillan Co.

AGRICULTURE.—A list of valuable Government papers on live agricultural topics. 87 pages. Paper cover. Washington, D. C.: Government Printing Office.

ADVANCE CHAPTERS FROM MINERAL RESOURCES OF THE UNITED STATES FOR 1906. Washington, D. C.: United States Geological Survey.

THE PRODUCTION OF ABRASIVE MATERIALS IN 1906.—By Douglas B. Sterrett. 16 pages.

THE PRODUCTION OF SULPHUR AND PYRITE IN 1906.—By David T. Day. 10 pages.

THE PRODUCTION OF LEAD IN 1906.—By J. M. Boutwell. 23 pages.

THE PRODUCTION OF FLUORSPAR AND CRYOLITE IN 1906.—By Ernest F. Burchard. 9 pages.

THE PRODUCTION OF QUICKSILVER IN 1906.—By J. M. Boutwell. 13 pages.

EXPERIMENTAL ELECTRICAL ENGINEERING AND MANUAL FOR ELECTRICAL TESTING; for engineers and for students in engineering laboratories.—By V. Karapetoff. 800 pages; illustrated. Bound in cloth. Price, $6 net. New York: John Wiley & Sons.

THE STORY OF IRON AND STEEL.—By Jos. R. Smith, 205 pages. Bound in cloth. Price, 75 cents net. New York: Robt. Appleton Co.

BRITISH INDUSTRIES.—By W. Ja. Ashley. A series of general reviews for business men and students. Second edition. 249 pages. Bound in cloth. Price, $1.80 net. New York: Longmans, Green & Co.

THOMAS ALVA EDISON.—By Francis Arthur Jones. Being sixty years of an inventor's life; with numerous illustrations from photographs. ("The author not only knows Edison intimately, but in the preparation of his book received the cooperation of many of Edison's friends, who gave him some very human details of the inventor's early life. The story reads like a romance. After years of struggle for a bare existence he was at twenty-two a full-fledged inventor, having sold his stockticker for $40,000. After this start the quadruplex telegraph, the dynamo, the incandescent lamp, the phonograph, the kinetoscope," etc.) 390 pages; many illustrations. Bound in cloth. Price, $2 net. New York: Thomas Y. Crowell & Co.

BOOK REVIEWS.

DIE ENGLISCHEN ELEKTROCHEMISCHEN PATENTE. By Dr. P. Ferchland, patent attorney in Berlin. Vol. I.:Electrolysis (Vol. XXIX of the German Monographs on Applied Electrochemistry). 176 pages; many illustrations. Price, marks 9.00 (retail price in New York, $3.00). Halle a. S.: Wilhelm Knapp.

This is the first of two volumes in which brief, concise abstracts are given of all English electrochemical patents. This first volume comprises the electrolytic patents. Their number

appears to be well over 1,000, to make a rough estimate. They are arranged simply in chronological order, the oldest English electrolytic patent having been granted in 1842, for the deposition of metals, especially platinum. The abstracts go down to the beginning of 1906. A subject index and a name index enable one to quickly find what is wanted. As a reference book the volume will be very useful.

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Les Decouvertes Modernes en Physique. By O. Manville. 186 pages; 32 illustrations. Price, 5 francs (retail price in New York, $1.35). Paris: Librairie Scientifique, A. Hermann.

This book discusses in concise manner the theory of "modern physical discoveries" in their relation to the hypothesis of the electric constitution of matter. The author shows that the electronic theory is nothing but a mechanical theory. While the "mechanical theory of yesterday" tried to explain the physical phenomena "in general, and especially the electric ones by the matter and its movement," the theory of to-day tries to explain everything by "the electricity and its movement."

The book discusses the passage of electricity through liquids and gases, the ionization of gases, electrons, the radioactive substances, the radioactivity of matter and the electronic theory of matter.

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The Metric and British Systems of Weights, Measures and Coinage. By F. Mollwo Perkin, Ph. D., Head of Chemistry Department, Borough Polytechnic Institute, London. 83 pages; 17 diagrams. Price, 50 cents net. London: Whittaker & Co.

This is a small book, primarily written "with the hope that those engaged in teaching chemistry, physics, engineering or general elementary science [in English schools and colleges] may find it useful to put into the hands of their students" as a connecting bridge from the British system of measures, weights and coinage to the metric decimal system. The hope is also expressed that the book "will be found useful to the business man and to the general public."

The keynote of the presentation of the subject in this book is simplicity. The author constantly endeavors to present the matter in the easiest possible way, to explain it by diagrams, and to give to his British-American readers a clear, concrete idea of the metric measures. Thus as a help to remember the length of a meter it is stated "that it is slightly longer than the yard, or the length is 3 feet 3 inches and 1/3 of an inch. This is easily remembered by bearing in mind 333." Further, to give an idea of the length of a decameter, reference is made to the cricket pitch, which is almost exactly 20 meters, or 2 decameters. To give an idea of the length of a hectometer, it is stated that the length of an ordinary English football field between the goal posts is nearly 1 hectometer and the width about ½ hectometer.

There is little to criticise. Why on page 11 a distinction is made between "Bulk: cubic meter, divided into 1,000 cubic decimeters," and "Capacity: liter, divided into 1,000 cubic centimeters," is not clear to the reviewer. Certainly it should be expressly stated at this place that 1 cubic decimeter is a liter.

The author arranges his subject by first taking up measures of length and of area, then weights and then volumes. Logically, the volumes should come before the weights, since the unit of weight is based upon that of volume and not reversely. Three further chapters on specific gravities, temperature measurements and money should prove useful.

Lord Kelvin said almost a quarter of a century ago: "I look upon our English system as a wickedly brain-destroying piece of bondage under which we suffer. I say this seriously. I do not think any one knows how seriously I speak of it."

The author of the present book says of the present situation in England: "At present it seems very difficult to get a bill through Parliament the object of which is to make the metric system compulsory, but surely it would be possible to pass a bill which would make the teaching of the system compulsory in every school in the land." Indeed, this would be a magnificent beginning.

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Transactions of the American Electrochemical Society, 1906.—Vols. IX. and X., meetings at Ithaca and New York City.

It may be of interest to our readers to hear what the *Electrical Review*, of London (which journal brings often good and concise notes on electrochemical engineering subjects), has to say on the *Transactions* of the American Electrochemical Society, since it is always useful to learn how others see us:

"The *Transactions* of the vigorous and enterprising American Electrochemical Society continue to be of the same varied interest and value that has characterized them since the very first issue, and, we may add, they are no less strong on the practical and experimental side, as they are—well, a little uncertain, let us say—on the theoretical side, than they ever have been. A list of the names of the fifty papers or thereabouts in these two volumes would probably come as a surprise to many people in this country who little realize the wide field that practical electrochemistry now covers. We cannot, of course, in a brief review do more than just draw attention to one or two of the more noteworthy out of a whole host of interesting papers. An important and most capable paper is a theoretical "Study of Resistance Furnaces," by Mr. C. L. Collens, in which the author deduces some general equations that should prove of considerable value to those engaged in the design of this type of furnace. A paper by Mr. E. A. Ashcroft on "Sodium Production" describes, in as much detail as the exigencies of business considerations will allow, his own very ingenious process. In this, unlike the Castner process, which now practically holds the field, and in which caustic soda is the electrolyte, the universal common salt is the raw material. This is electrolyzed in a double apparatus, in the first of which the sodium alloys with molten lead, while the clever device of setting up a strong magnetic field in the cell maintains the liquid cathode and the electrolyte in circulation. Mr. Sperry's note on "Electrochemical Processes as Station Load Equalizers" raises points well worthy of the consideration of electrical engineers who are worried by peaks. The electric vacuum furnace, which Mr. Aisem, of the American G. E. C., describes, is a new type of furnace now coming into use both as an instrument of research and for some small industrial processes. A suggestive paper by Prof. C. F. Burgess and Mr. O. P. Watts discusses the structure of electro-deposited metals, but it deals only with the outskirts of the subject, and we still await a really comprehensive study of a matter second in importance to none with which the electrometallurgist has to concern himself. There are now several electrochemical laboratories in England, and a subject such as this is preeminently suitable for research students to tackle under able guidance. A controversial paper by M. Le Blanc discusses the possibility of depositing by electrolysis thick layers of coherent metallic chromium, and the author concludes—a conclusion not shared by his critics—that this cannot be done. Of broader interest are several useful papers on "Pyrometry," and, lastly, we have a detailed description by Prof. Crocker of an improved and quite business-like variety of primary battery of the bichromatic type, made by Mr. F. A. Decker, which, judging by the tests submitted, should help to popularize the use of batteries in those many cases where their trouble and cost at present put them out of court.

"Altogether, the varied fare provided in these *Transactions* is well worthy of careful study by everybody who wishes to be posted in what practical electrochemistry is doing in the most go-ahead country in the world."